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The HUMAN BODY IN PICTURES

JACOB SARNOFF M.D.

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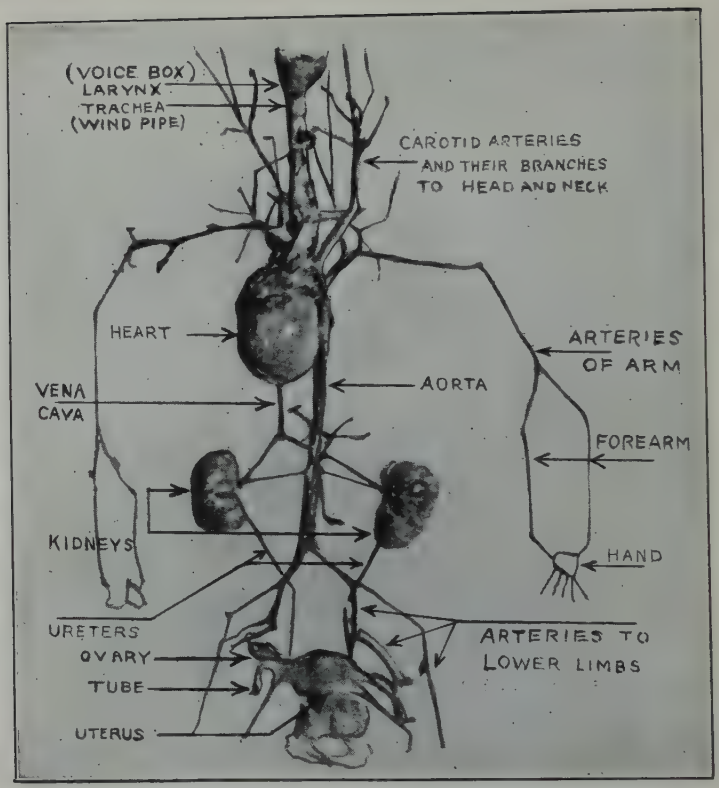
The Human Body in Pictures. A Visual Text of Anatomy, Physiology and Embryology, by JACOB SARNOFF, M.D. Physicians and Surgeons Book Company, Brooklyn, New York. Pp. 120.

The book is a "manual" of a series of motion pictures, illustrating the development and physiology of the principal systems of the body. It is very difficult to see how the book itself could be of any value to men taking courses in a first-class medical school. The films, however, have been used successfully in the teaching of student nurses and in the instruction of hospital corpsmen in the Army. BM+SJ 7/28/27

THE HUMAN BODY IN PICTURES



DISSECTION OF THE HEART AND BLOOD VESSELS.

THE HUMAN BODY IN PICTURES

A VISUAL TEXT OF ANATOMY, PHYSIOLOGY AND EMBRYOLOGY

BY

JACOB SARNOFF, M.D.

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With Foreword by
JOHN OSBORN POLAK, M.D.

With 190 original illustrations, mostly from dissections and animated drawings by the author

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Dedicated

TO STUDENT AND TEACHER

TO

LIGHTEN THEIR TASK

FOREWORD

Some understanding of the anatomy and physiology of those systems of the human body upon which life depends should be included in the education of every boy and girl. For what is more vital to the health of mankind than a knowledge of the great mechanisms of circulation, respiration, digestion and reproduction, and how much more readily can these mechanisms be appreciated when the subject is presented on the screen with an explanatory text.

In the following pages the author illustrates, describes and correlates the development, structures and functions of the human body in such a readable and accurate manner as to be understandable alike by the high-school student and the professional aspirant who desires to review the fundamentals of the pre-clinical sciences.

More subjects should be treated in this simple manner, which is not a new form of presentation, but is so well exemplified in this little book.

John Osborn Polak.

PREFACE

It is the purpose of this manual to illustrate, describe and correlate the development, structure and functions of the human body. The manual is also intended to serve as a teaching and explanatory guide for the student and teacher to be used in collaboration with a visual text of a series of motion picture films and film slides of "The Human Body" which it closely follows and describes in detail.

The great difficulty confronting the average individual in the study of the human body lies in the inability to visualize and readily follow its development, structure and functions, as presented in the average textbook of Anatomy and Physiology.

The advantages of motion pictures, to be used in collaboration with the text, are many. Motion pictures represent vivid action as compared to textbooks, which are, at best, merely descriptions of facts and actions. To study this text in conjunction with the film, which it closely follows in detail, is to photograph and then fix in the mind of the student the biologic phases of human life.

A work of this character is of a pioneer nature, and as such the author feels keenly its difficulties and is aware of its many shortcomings; for these he begs indulgence. The purpose of this work, let it be understood, is not to displace lectures and textbooks, but rather to supplement and to be used in conjunction with them.

A word of explanation as to the arrangement of the text:

Each subject is treated in a separate chapter which corresponds to a similar reel of the subject in film slides and motion pictures. In the still picture edition of the film, the

frames in each reel are numbered consecutively, bearing the same numbers as its descriptive text in the manual. The illustrations in this manual (which are taken directly from the motion picture film) likewise have the same numbers. One may thus view the film slides and read its descriptive text in the manual at the same time.

The manual may also be used independently as it contains a sufficient number of scenes selected from the film to enable the reader to visualize clearly and follow the facts as stated in the text, by alluding to these illustrations.

When descriptive words are used signifying their anatomical location (such as right or left, front or back, upper or lower), they refer to the position of the parts as they appear in the body. Words in parentheses are generally explanatory notes, synonyms, or more technical terms, used in connection with the simpler terminology.

Practical facts and hints are interposed along with the text when they have some interesting or important bearing on the subject under discussion, such as the significance of appendicitis, peritonitis, gall stones, diabetes, adenoids, enlarged tonsils, mouth breathing, hoarseness, bronchitis, pleurisy, kidney stones, heart murmurs, high blood pressure and heredity. Proper hygienic measures are likewise emphasized, which materially aid in the normal functioning of the organs and their systems during the various phases of their activity such as digestion, respiration, elimination, circulation and regeneration.

This series of motion picture and still picture films is intended primarily for students of Anatomy and Physiology. In connection with this illustrative and descriptive text, it is especially adapted for schools, colleges, nurses' training, physical education, and to provide for the lay mind a clear understanding of the essential structures and functions of the human body. To medical students, as well

as graduates, it may prove an interesting review of these subjects.

The ideal method of teaching Anatomy and Physiology to classes is to utilize these visual aids in the following manner: The subject of one reel is taken up at a lecture. The first part of the lecture is devoted to a presentation of the particular subject by means of the still picture film slides, at which time the teacher may utilize this manual as the text for his lecture. He may elaborate, however, on interesting or important details, depending upon whether the class is made up of elementary students of biology, or nurses, dental or medical students. The still pictures make it possible to dwell on a particular point of interest without the fleeting effect of motion pictures. The balance of the lecture may profitably be spent in viewing the same reel in motion pictures, which gives the student a complete and effective review of the subject.

JACOB SARNOFF

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TABLE OF CONTENTS

INTRODUCTION.

REEL 1—THE DIGESTIVE SYSTEM.

REEL 2—THE RESPIRATORY SYSTEM.

REEL 3—THE URINARY SYSTEM.

REEL 4—THE CIRCULATORY SYSTEM: THE HEART AND HOW IT WORKS.

REEL 5—THE CIRCULATORY SYSTEM: THE BLOOD VESSELS AND THEIR FUNCTION.

REEL 6—REPRODUCTIVE SYSTEM AND HUMAN DEVELOPMENT.

LIST OF ILLUSTRATIONS

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INTRODUCTION

ARCHITECTURE OF THE HUMAN BODY.

Our **living organism** is made up of a framework (*skeleton*), jointed at various parts by *ligaments,* and clothed with an adequate supply of contractile bands (*muscles*) to enable locomotion. The framework, with its various muscles, is smoothed, rounded out, and kept in proper alignment and position by connecting parts (*connective tissue*), softly padded by pliable cushions of *fat,* and completely covered with the finest upholstered waterproof material—the *skin.*

This structure (framework) is arranged to house the various departments of the industry constituting life. The executive office (*the brain*) is safely housed in the upper compartment (*the skull*). Through the medium of the *spinal cord,* representing its main telephone trunk line, and the various *spinal nerves* which branch from it, representing individual telephone stations, the brain controls and is aware of all activities of the body.

The various units (the *cells* which compose the many tissues and organs of the body) are furnished with a proper amount of material for their activity, through the medium of the "floating currency"—the *blood,* which is pumped by the heart through channels—the blood vessels, to all parts of the body.

The middle compartment (**the thorax**) is made up of a solid framework consisting of twelve *ribs* on each side, attached at the back to the twelve thoracic *vertebrae* of the spinal column, and held together in front by the breastbone (*sternum*). The thoracic cavity houses the heart and its main blood vessels, the lungs and the breathing tubes.

CELLS; TISSUES; ORGANS; SYSTEMS.

The lower compartment (**the abdomen**) is made up mostly of soft walls of muscle tissue, except at the back where the lumbar vertebræ of the spinal column form part of its wall. In the abdominal cavity are situated most of the organs of the digestive, reproductive and urinary systems.

The three compartments, the head, thorax and abdomen, are held together in proper alignment by means of the spinal column. The spinal column also serves to transmit, through its canal, the spinal cord from which spring all the spinal nerves passing to all parts of the body.

The spinal column is made up of twenty-four separate segments of solid bones (*vertebræ*), *sacrum* and *coccyx* which are held together firmly by *ligaments,* forming the main pillar (backbone) of the framework (skeleton). The head is pivoted on top of the spinal column. To either side, attached to the upper end of the thorax, through the medium of the shoulder-blades (scapulæ) and the collar bones (clavicles), are the upper limbs. To the lower end of the spinal column is attached the bony pelvis (hip-bones). The lower limbs are attached to either side of the bony pelvis by a round jointed articulation connecting the thighs with the pelvic bones.

The *human body* is made up of a collection of *cells* woven into many fabrics (*tissues*) which combine to form the different *organs.* Each organ is assigned to a specific duty. All the organs which cooperate to perform certain functions are grouped into *systems.*

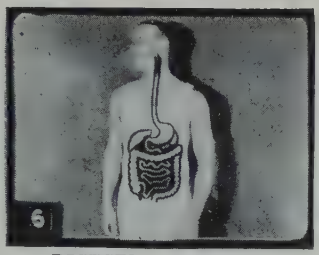
Our living organism contains among its many systems:—
A Chemical Laboratory—Digestive Tract
A Ventilating System—Lungs and Breathing Tubes
A Filter Plant—Urinary Organs
A Ceaseless Motor—Heart

RELATIVE POSITION OF ORGANS IN BODY.

A System of Elastic Tubes—Blood Vessels
A Generative Plant—Reproductive System
An Executive Office—Nervous System

The organs of the nine main systems are guided and controlled by the brain and nerves (nervous system). They perform in close harmony and cooperation their many varied functions, such as digestion, respiration, excretion, circulation and reproduction, in the small and compact space allotted to them in the human body.

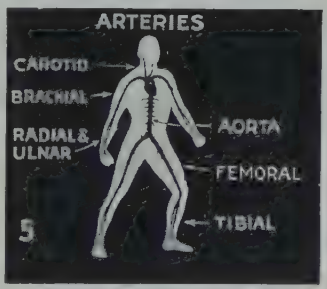
The subject presented and discussed in this visual text include: The Digestive System, Respiratory System, Urinary System, Circulatory System and Reproductive System. The organs of these various systems, their development, structure and functions and their relative positions in the body are illustrated with the aid of the explanatory animations, anatomical dissections and the action of living organs.



DIGESTIVE SYSTEM

URINARY SYSTEM

RESPIRATORY SYSTEM

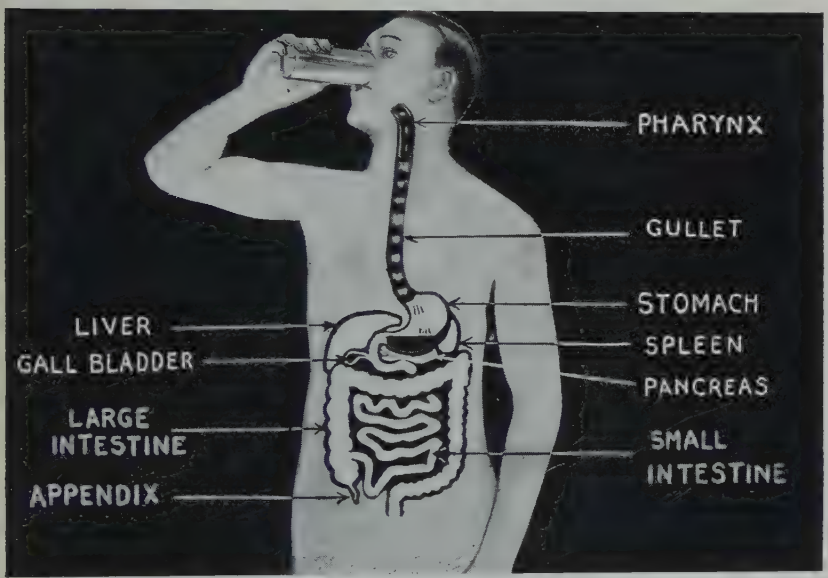


CIRCULATORY SYSTEM

THE HUMAN BODY IN PICTURES

REEL 1—THE DIGESTIVE SYSTEM

The purpose of the Digestive System is to break up (masticate) the food into fine particles, receive them into the various parts of its channel (digestive tract), incorporate them with the various secretions (ferments) produced (secreted) by the glands of its tract and the accessory organs of digestion (salivary glands, liver and pancreas) so as to digest (convert) the food into a form which can readily be taken up (absorbed)



* FIG. 74. THE PASSAGE OF FOOD THROUGH THE DIGESTIVE TRACT

from its tract into the blood to be distributed as nourishment to all parts of the body.

19-21. The Digestive System consists of the alimentary

* The numbers for the illustrations in this manual are not in a consecutive order, and in each chapter the numbers start separately. This is explained by the fact that the illustrations are selected from the film slides in which the scenes are arranged and numbered separately for each reel or system. For reference, therefore, both the number of the scene as well as its page are stated in the text.

canal, together with its accessory organs which receive and digest the food.

21. **The Alimentary Canal** (digestive tract) consists of the mouth, pharynx, gullet, stomach, small and large intestines and appendix. The Accessory Organs include the salivary glands, liver, pancreas and gall bladder. (See fig. 74, p. 25.)

22. ***The Pharynx** is five inches long, situated at the upper portion of the neck, connecting the mouth to esophagus.

23. **The Esophagus** (gullet) is ten inches in length. The upper portion is situated in the neck, the lower portion is in the thoracic cavity. It connects the pharynx to the upper (cardiac) end of the stomach.

Digestion begins in the mouth during the process of mastication and insalivation, when the food is broken up into fine particles and mixed with saliva (the secretion produced by the submaxillary sublingual and parotid glands, which is conveyed to the mouth through the ducts of these glands).

24. **The Stomach**—is a receptacle for food where the main process of digestion is continued. It is situated in the upper left portion of the abdomen, lying in close contact with the liver, diaphragm and spleen. The upper opening is called the cardiac opening; the lower opening is the pyloric. The shorter and upper border is called the lesser curvature; the longer or lower border, the greater curvature of the stomach. The capacity of the stomach is about one quart. (Figs. 37-38, p. 30.)

25. **The Small Intestine**—extends from the lower pyloric opening of the stomach to the opening into the large intestine at the cecum. It is about twenty feet in length. Its upper ten inches is called the *duodenum,* the upper remaining two-fifths the *jejunum,* the lower three-fifths the *ilium.*

* For class teaching, when the manual is used in conjunction with the film slides, it is advisable for one of the members of the class to read the text of the manual while the teacher points out on the screen the various anatomical parts and biologic phases as described in the text.

ileum

APPENDIX—LARGE INTESTINE—PANCREAS

Digestion and absorption take place in the small intestine. (See figs. 35, 40, 42.)

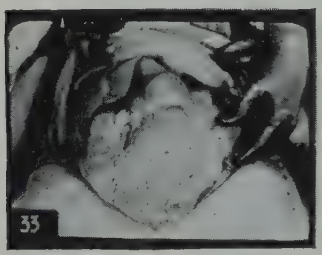
26. **The Appendix**—is a narrow worm like tube situated in the right lower portion of the abdomen at the beginning of the large intestine (cecum). It is about three to six inches in length, and as thick as a lead pencil. While all organs continue to grow after birth, the appendix remains almost stationary: it is about the same size in the adult as in the new-born. (See fig. 59, p. 32.) Because of its small diameter, as compared to the lumen of the large intestine, particles of food often fall into its narrow opening and are unable to pass out again. This quite often causes a blocking of the secretion in the appendix, causing it to swell and even to burst, producing *appendicitis* and its serious consequences. The pain in appendicitis is most often felt in the right lower portion of the abdomen where the appendix is situated.

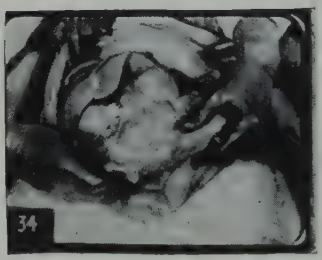
27. **The Large Intestine (colon)**—is about five feet in length, about twice as wide as the small intestine. It is horseshoe shaped and in the center of it is situated most of the small intestine. (See fig. 42, p. 30.)

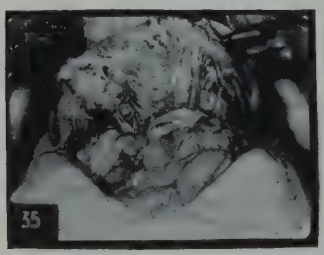
That portion of the large intestine below the opening of the ilium is called the *cecum*. The appendix extends from the lower portion of the cecum (see fig. 59). *The ascending colon* extends from the cecum to the under surface of the liver (fig. 78), the transverse colon extends from the under surface of the liver at the right, to the spleen at the left (fig. 79). The *descending colon* passes from the spleen towards the pelvis to terminate in the lower portions called the *sigmoid* and *rectum*. (See fig. 80.)

28. **The Pancreas (sweetbread)**—is situated below the stomach and above the large intestine, surrounded by the duodenum. The pancreas secretes a fluid which passes through its duct into the duodenum to help digest the food especially starches, sugars and fats. It is considered an *external secre-*

POSITION OF LIVER, STOMACH, LARGE OMENTUM AND INTESTINES IN THE ABDOMINAL CAVITY







tion because it does not enter the blood stream. The pancreas also secretes a fluid called *insulin* which enters directly into the blood stream and is therefore called an *internal secretion.* When certain parts of the pancreas are diseased, diminishing the supply of insulin, diabetes may result. Insulin obtained as an extract of the pancreas of various animals such as the pig, ox, etc., has been discovered, which when injected into those having diabetes will free them from the excess of sugar in the urine and blood, and thus greatly relieve them.

29. **The Liver**—is the largest gland in the body. It forms (secretes) bile, is a storehouse of energy (glycogen) and a blood purifier. It is situated in the upper right portion of the abdomen in contact with the diaphragm, stomach, duodenum and large intestine. It weighs about three pounds. (See fig. 48, p. 31.)

The main organs of the digestive system lie in the abdominal cavity. (Figs. 31-61.) The abdominal cavity is opened (fig. 31) and the flaps

THE ORGANS OF THE ABDOMINAL CAVITY DEMONSTRATED BY THE PNEUMO-VISCERA METHOD

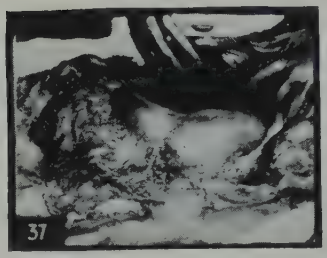
of the abdominal wall are reflected to either side. The abdominal cavity is lined with a thin, smooth, glossy covering called *peritoneum.* It lines the inner walls of the abdomen and surrounds all the organs of the abdominal cavity. The peritoneum allows the various organs to glide smoothly in the cavity with the least amount of friction and forms supporting folds (mesenteries) to hold the various organs in place. *Peritonitis* is an inflammation of the peritoneum. It generally occurs secondary to an inflammation of the organs which it surrounds, such as the appendix, gall bladder, intestines, uterus, tubes, ovaries, etc. The liver is above and to the right, underneath the diaphragm. The stomach is to the left, the large omentum (apron) is below and covers the intestine.

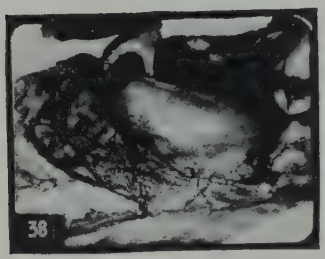
33. The diaphragm is raised exposing the *liver,* showing its upper surface, its free border and part of its under surface. It is in contact with the *stomach* and colon. Below the stomach, the *large omentum* comes down as an apron.

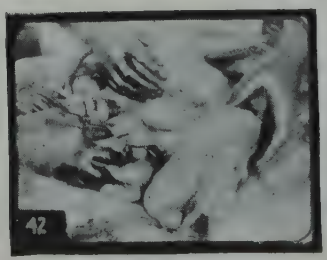
34. The large omentum with the *transverse colon* is raised and reflected upwards, exposing the *transverse mesocolon* and the many coils of *small intestine* (fig. 35).

37-38. The various organs and parts of the body, their size, shape, capacity, elasticity, and their relations to surrounding structures, are more clearly visualized in this text, wherever feasible, by a method conceived and designated by the author as the "Pneumo-Viscera Method." It is a means of demonstrating the various organs of the body in position (in situ) by inflating them with air.

Procedure: A cannula (tube) with an atomizer bulb attached (figs. 50, 57) or any other arrangement whereby air may be introduced into the cavity of an organ, is inserted into such cavity through its leading canal, or directly into the cavity. It is inserted into the esophagus for the inflation of the







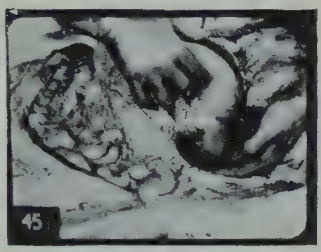
digestive tract, into the trachea for the inflation of the lungs, into the gall bladder for the inflation of that organ and its ducts; similarly the pancreas, the bladder, the kidneys, the uterus, the vascular system, etc., may be demonstrated.

(Note. The organs in figs 37-51 are viewed from the left side of the body.)

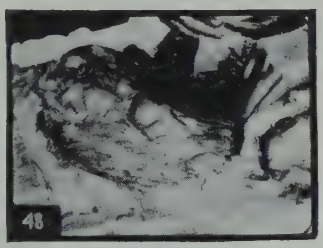
37. The stomach is thus partly inflated showing clearly its size, shape, capacity and its relation to the surrounding structures; the lesser and greater curvatures, the fundus, body, pyloric portion, and anterior surface of the stomach. The liver is raised exposing its under surface, the lesser omentum which extends from the under surface of the liver to the lesser curvature of stomach, and the greater omentum which descends from the greater curvature as an apron to cover the small intestine.

38. The stomach is fully inflated showing its capacity. Overloading of the stomach is unhealthful. It expands beyond its normal limits, forcing the diaphragm upward, pressing on the heart and

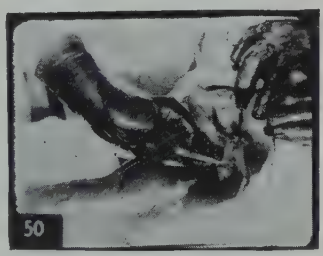
lungs above, producing palpitation (throbbing of the heart), dyspnea (shortness of breath), and indigestion. (See figs. 23-26, p. 41.)



40. The twenty feet of *small intestine* are arranged in coils and held together by the mesentery (supporting folds of peritoneum), which is attached to the posterior wall of the abdomen.



42. **The Large Intestine**—is about twice the diameter of the small intestine. It is attached by its mesentery (mesocolon) to the posterior wall of the abdomen. The jejunum begins below and to the left of the mesocolon.



43. **The Colon**—to the left near the spleen is bent at an angle. This angle is called the *splenic flexure.*

45. **The Spleen**—is a large ductless gland and a blood forming organ whose functions are imperfectly understood. The spleen is situated to the left of the stomach, to which it is attached by its ligament. Its anterior border is notched.

47. Abdominal organs in situ (in position). The liver is above to the right, the stomach to the left, the large omentum below.

48. The Liver is lifted up by its round and falciform (sickle-shaped) ligaments.

50. **The Gall Bladder**—is a pear-shaped sac which lies

under the liver. It stores and concentrates the bile which is discharged into the intestine as needed. A tube (cannula) is inserted into the gall bladder at its fundus (top). The common duct is clamped near the duodenum by a forceps. The gall bladder is situated at the under surface of the liver. It is distended (inflated) with air by the Pneumo-Viscera Method, to show the exact outline of the gall-bladder, its *fundus* (top portion), the *body* (middle portion) and the *neck* (lower trap-shaped portion), the Y shaped arrangement of the *cystic* and *hepatic ducts* and the *common duct* (fig. 51) as it passes behind the duodenum which it enters. **Gall-stones** form in the gall-bladder when the bile thickens. When a stone drops from the gall-bladder into its narrow ducts it may block the flow of bile, distend or even rupture the gall-bladder, producing colicky pain and jaundice.

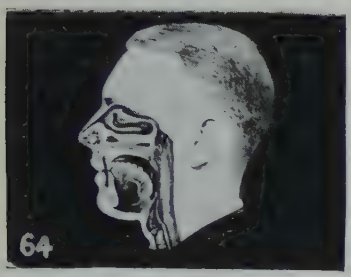

55


57


59

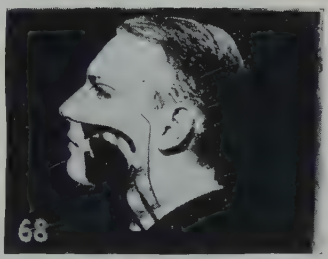
55. **The Abdominal Organs of the New-born:** A cannula (tube) connected with an atomizer bulb, is introduced into the esophagus and the digestive tract is inflated with air to demonstrate in situ (position) their size, shape, elasticity and their

THE EPIGLOTTIS—ITS FUNCTION IN DEGLUTITION (SWALLOWING)



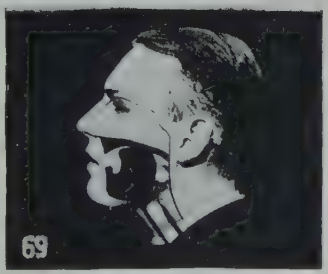
relation to the surrounding structures. The *stomach* is distended. In the new-born it holds about one ounce. The coils of *small intestine* (in this specimen) are as yet not inflated. They appear of a light color. The *large intestine* surrounds the small intestine, is of a darker color due to the meconium (bowel contents of the new-born) which is of a tarry appearance and consistency.

57. The *small intestine* is inflated. Its coils become more distinct.

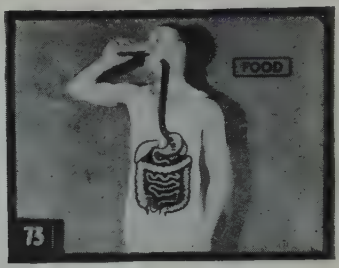


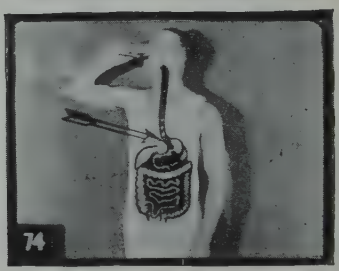
59. **The Appendix** — extends from the lower part of the cecum, is at times coiled up like a worm, situated at the junction where the ilium enters the cecum.

61. **The Sigmoid** — the lower portion of the large intestine, passes down into the pelvis (as indicated by the forceps and finger).



THE PASSAGE OF FOOD IN THE ALIMENTARY CANAL



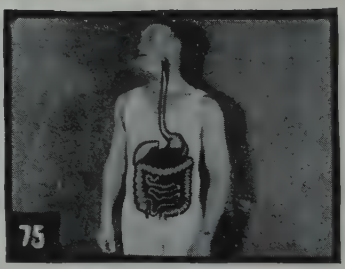


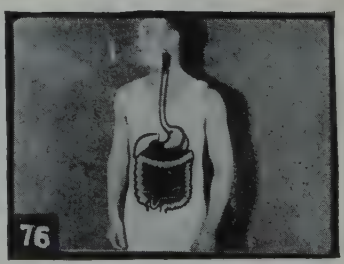
The Passage of Food in the Alimentary Canal. (Figs. 62-82.)

64. A cross section of the head, showing the interior of the nose, mouth, pharynx, and larynx, including the *epiglottis*.

67. A diagrammatic drawing of the tongue, palate, teeth and epiglottis, presented in black. A morsel of food in the mouth (*buccal cavity*) is on its way to the stomach, held between the tongue and hard palate (roof of the mouth).

68. As the swallowing (*deglutition*) of the food begins, the tongue





THE PASSAGE OF FOOD IN THE ALIMENTARY CANAL

rises, forcing the food backwards towards the pharynx.

69. As the food passes to the *pharynx* the *soft palate rises* to prevent the food from entering the nose. *The epiglottis comes down as a lid* to cover the larynx, to prevent the food from falling into the wind-pipe.

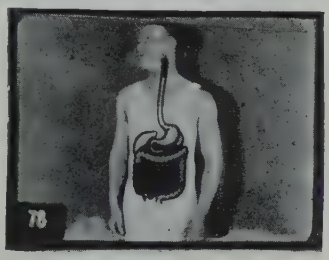
Should a particle of food accidentally fall into the larynx (voice-box) a choking sensation is experienced with a resulting cough (nature's effort to expel it).

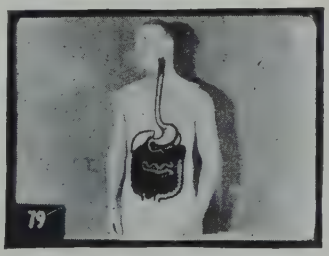
70. The food is then safely on its way in the gullet to reach the stomach. (Fig. 71.) The soft palate and the epiglottis then resume their normal position.

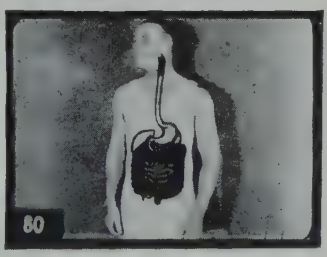
73-74. From the *esophagus* the food enters the stomach.

74. The *stomach* then becomes filled. The food is here partly digested. The valve (pyloric sphincter) at the lower end of the stomach prevents the food, for a short time, from passing into the small intestine.

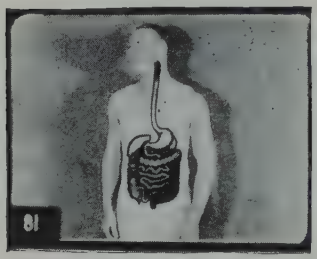
75. At brief intervals the stomach contracts producing peristaltic waves. The pyloric valve opens, forcing some of the liquefied food

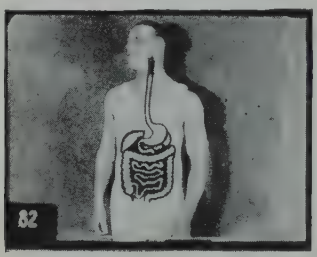






ABSORPTION AND CONVERSION OF FOOD INTO ENERGY





(chyme), which is partly digested, to enter into the small intestine.

76. As the stomach empties the *small intestine* becomes filled. Here most of the nourishing part of the food is digested and absorbed.

77. At intervals the small intestine contracts (peristalsis). The valve (sphincter) at the junction of the ilium and cecum opens, and the liquid food (chyme) enters into the large intestine.

77-81. As the food empties from the small intestine, the *large intestine* becomes filled, the food passing up into:—(78) The Ascending Colon, (79) The Transverse Colon, (80) The Descending Colon.

81. In the *large intestine* a small portion of the remaining food and a good deal of the water is absorbed into the blood. The contents, as a result, become semi-solid (soft) and are kept in the lower part of the bowel (sigmoid and rectum) until evacuated. It requires about 12 hours for the average meal to be digested and absorbed by the blood.

84. Diagrammatic drawing of the heart and blood-vessels —and the parts which they supply: The tube in the center represents the intestines. (See fig. 24, p. 78.)

Food is absorbed from the *intestines* by the blood, which enters the large vein (called the *portal vein*) to reach the *liver*. Note: The lymph duct (*Thoracic Duct*) also carries some of the nourishing elements (*chyle*) from the intestine into the blood stream. (See fig. 46, p. 79.)

THE PROPER ASSIMILATION OF FOOD

85. In the liver a good deal of the nourishing food is stored as energy in the form of sugar (*glycogen*).

86-99. From the liver the nourishing blood passes through the inferior vena cava to the heart from which it is distributed to all parts and tissues of the body, such as:—

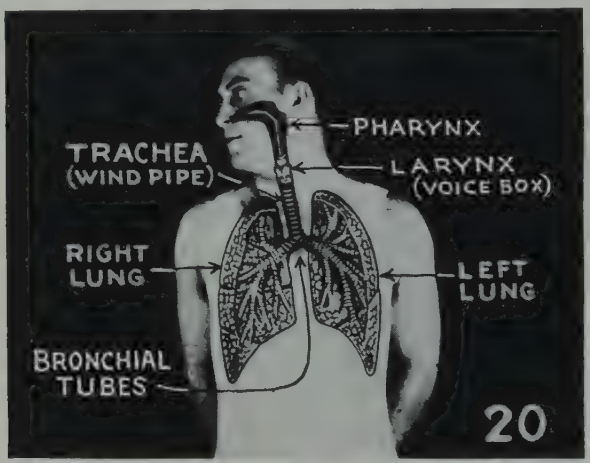
bones skin brain muscles	where it is converted into ENERGY OF	growth heat thought action

As can readily be seen, the chemical laboratory, the digestive tract, is a complicated tubular canal thirty feet long, where the food is received and with the aid of its own glandular secretions and those of the salivary glands, liver and pancreas, is digested and converted into a form most suitable for conveyance by the blood to furnish the body tissues with the necessary energy for human activity.

The proper functioning of the digestive system depends a great deal upon the quality, quantity and type of food as well as the manner in which it is consumed. Wholesome food, thoroughly masticated, taken in moderation at regular intervals three times a day under pleasant surroundings, aids materially in the normal functioning, growth and development of the human body.

REEL 2—THE RESPIRATORY SYSTEM

The purpose of the Respiratory System is to supply the body cells with the oxygen necessary for the process of oxidation, which continually takes place in order to build tissue, maintain body heat and furnish energy for human activity. It also rids the body cells of the excess of carbon-dioxide resulting from this oxidation, and helps to equalize the body temperature and get rid of the excess water.



The organs of respiration consist of the *nose, pharynx, larynx, trachea,* two *bronchi,* and two *lungs.* (See fig. 20.)

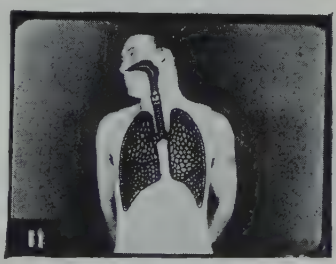
6. Cross section of the head showing the interior of the nose (*nasal passage*) which is separated from the mouth by the *palate.* The outer wall of the nasal passage contains three curved bones (*turbinates*) lined with mucous membrane, richly supplied with blood. The inhaled air is moistened and warmed as it passes by this warm and moist lining of the nose.

NASAL PASSAGE—PHARYNX—LARYNX

7. **The Nasal Passage**—extends from the *nostril* in front to the back of the nose (*choana*) which becomes continuous with the upper portion of the pharynx. In the upper portion of the pharynx, adenoids (lymph tissue) sometimes grow, which may cause an obstruction to the passage of air through the nose, forcing the individual to breathe through his mouth (mouth breathing). The floor of the nasal cavity is formed by the palate which also forms the roof of the mouth. Below the palate is the mouth (*oral cavity*) containing the teeth, tongue, etc.

8. **The Larynx** (voice-box) or "Adam's apple"—is situated in the upper front portion of the neck, below the chin. Its anterior prominent portion (Adam's apple) can readily be seen to move up and down during swallowing, especially in thin people.

9. Interior of larynx — The *vocal cords* are situated to either side of the middle of the larynx. The opening into the larynx is called the *glottis,* which communicates with the pharynx above. The covering to the larynx (the lid) is the *epiglottis.* (See figs. 6 and 54, 55, p. 46.)



10. Below the interior of the larynx is the trachea (wind-pipe).

11. **The Respiratory Organs**—including the nose, pharynx, larynx, trachea, the two bronchi and two lungs with their five lobes,

as they appear in their relative position in the body. (See fig. 20, p. 38.)

12. **The Pharynx**—connects the nose to the larynx as well as it connects the mouth to the gullet. In other words the pharynx is a common passage for both air and food.

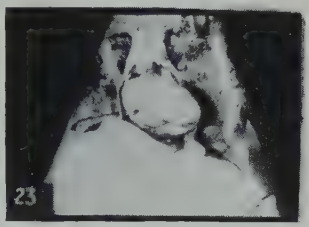
13. **The Larynx**—connects the pharynx to the trachea.

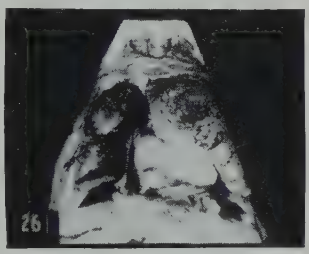
14. **The Trachea** (wind-pipe)—is a rigid, constantly open tube four and one-half inches long, three quarters of an inch wide, composed of about eighteen rings of cartilage interposed between the soft wall of fibrous tissue in the trachea. The trachea divides at the upper portion of the chest (at the level of the fourth dorsal vertebra) into two bronchi (fig. 15). Like the trachea the bronchi contain cartilaginous rings to keep them rigid and open for the passage of air.

18-20. **The Bronchi and their Branches:** The right and the left bronchi, as they enter the lungs, divide and subdivide, like a tree, into many branches. These fine branches terminate as air-cells in the lung tissue termed *alveoli* (air spaces) which are analogous to the leaves of a tree. The surface of the lungs exposed to the air in the alveoli is about one hundred times greater than the entire skin surface, being ninety square meters, while the skin surface is about nine-tenths of one square meter. In the air spaces (alveoli) the oxygen from the lungs enters the blood and the carbon dioxide from the blood enters the alveoli of the lungs. The blood, as a result of this exchange, which is called "External Respiration," becomes arterial (red in color).

22-26. *The lungs* surround and partly cover the heart.

INTERIOR VIEW OF THE CHEST: HEART AND PERICARDIUM—LUNGS AND PLEURA—DIAPHRAGM





23. **The heart and lungs,** and their relation in the thoracic cavity: The anterior chest wall and part of the sac enclosing the heart (pericardium) are removed to show the relative position of the lungs and the heart. The right and left lungs are held apart to show their concave inner surfaces leading towards the roots (hilus) of the lungs in the back, and their sharp anterior borders in front. The space between the two lungs in the thoracic cavity is called the *mediastinum.* The heart is placed in the center (middle mediastinum) enclosed in a separate compartment (*the pericardium*), so that when the heart beats, it moves in its own smooth chamber (pericardial sac), without interference from surrounding structures, such as the lungs and chest wall.

24-26. The lungs and inner chest wall are lined with a thin, smooth, glossy covering called the *pleura.* (See fig. 65, p. 82.) Each lung is enclosed in a separate compartment (pleural sac) forming the right and left pleural cavities, separated in the center by the heart

and its sac (pericardium) which surrounds it. The pleura allows the lungs to glide smoothly in the chest cavity during breathing movements (respiration). *Pleurisy* is an inflammation of the pleura. Its smooth surface becomes roughened producing friction between its surfaces during breathing (*dry pleurisy*). This rubbing (friction) produces severe pain on drawing of the breath. Later a fluid (effusion) may be poured out between its surfaces. This fluid (in *pleurisy with effusion*) separates the surfaces of the pleura and thus prevents the friction and pain. As the fluid becomes excessive it compresses the lungs and often displaces the heart to the right, producing shortness of breath (*dyspnea*) and throbbing of the heart (*palpitation*). The fluid may have to be removed (aspirated) to relieve the pressure.

26. During inspiration the lungs become inflated, fill up the chest cavity, surround and partly cover the heart. Note that the lower surfaces (bases of the lungs) together with the under posterior surface of the heart in its pericardial sac, rest on the dome of the diaphragm which separates them from the abdominal organs. *The right lung,* situated in the right pleural cavity, is divided by *two fissures* (notches) into *three lobes.* (See fig. 11, p. 39.) One fissure is between the *upper* and *middle* lobe, the other between the middle and *lower* lobe. The right and the left lung are separated from the heart by the pericardial sac which is attached below to the dome of the diaphragm. The upper lobe of the left lung is in front and partly covers the heart. The lower lobe is in a more posterior position. Very little of this lower lobe is seen in front and below. The lungs are mottled

(spotted black) due to the deposits of coal-dust, etc., which are inhaled and accumulated in them during the course of life.

33-34. *The left lung has two lobes.* It is lifted forward from the left pleural cavity. A fissure (notch) divides the left lung into an *upper* and a *lower lobe.* (See figs. 11, 34.) The upper lobe is more anterior. The lower lobe is more posterior. The fissure between the lobes extends from below and in front upward and backward. The under surface of the lower lobe rests on the dome of the diaphragm.

36. At about the middle of the body (as indicated by the hand) the lower part of the ribs form an arch (the *costal arch*) at which level the *diaphragm* is attached, separating the chest (thoracic cavity) from the abdomen (abdominal cavity). (See fig. 37.)

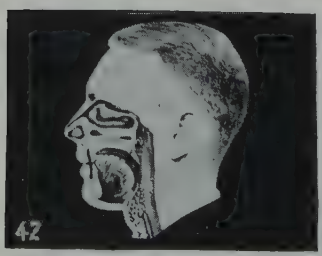
37. **Anterior view of thoracic and abdominal cavities:** Their anterior walls are removed leaving only the *costal arch* with the *diaphragm* which separates the thoracic from the abdominal cavity.

38. The costal arch, with the diaphragm, is pulled downwards exposing its dome above and the abdominal organs below.

40-41. **Respiration** (breathing) consists of *inspiration*——inhaling (See fig. 50), and *expiration*—exhaling (See fig. 49).

40. During *inspiration* (See fig. 50) the chest expands, the ribs become more prominent, the diaphragm contracts and descends, creating a negative pressure in the chest which expands the lungs and sucks in the air. The lungs communicate with the outer air through the nasal passage and breathing tubes.

COURSE OF THE AIR DURING INSPIRATION



42-43. As a result of suction in the lungs during *inspiration,* air enters through the nostrils, where the hair (vibrissae) filters (checks) particles of dust, etc., and passes into the nasal cavity where it is warmed and moistened. From the nasal passage, the air enters the pharynx. When *adenoids* (growth of lymph tissue) are present at the back of the nasal passage, they obstruct the flow of air from the nose, forcing mouth breathing, which is abnormal. The mouth (oral cavity) is not equipped like the nose to filter, moisten and warm the air as it passes to the lung. *Mouth breathers* have a typical languid expression (mouth kept open). The cold dry air predisposes them to dryness of the throat, colds, irritation, inflammation and infections of the respiratory tract, such as laryngitis, hoarseness, bronchitis, pneumonia, etc. *Adenoids* and *tonsils,* when enlarged or diseased, should therefore be removed to avoid such complications.

The air then passes through the *pharynx,* which is a common canal for the passage of food as well as air. From the pharynx it enters the *larynx,* as its opening (glottis)

widens, to allow the air to pass through freely. The air then passes through the *trachea* and *bronchi* to reach the *lungs.* (See figs. 54-63.)

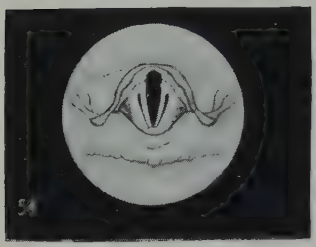
During *Expiration*—The muscles of inspiration relax, allowing the chest to resume its original size, as a result of which the elastic lung tissue contracts and the air is expelled from the lungs and passes in the opposite direction. (See figs. 44, 49.)

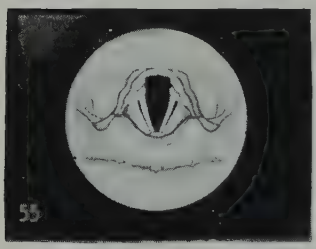
48-50. During *Inspiration*—The ribs are raised (by the action of the intercostal muscles, etc.) and become more prominent. The chest widens, the diaphragm contracts and descends, producing a groove below the ribs to which it is attached. As the chest cavity widens, lengthens and deepens a *vacuum* is created in the cavity which causes the elastic lungs to stretch (like bellows) and adhere to the inner chest wall; the lungs as a result expand, create a suction in the breathing tubes which tends to inflate the lungs with air. The average rate of respiration is about eighteen times per minute. We therefore breathe once to every four beats of the heart. With each inspiration we inhale about thirty cubic inches or one pint of air.

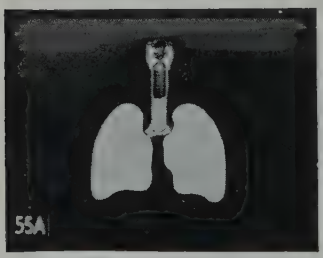
51-52. An animated diagram of breathing. The air during inspiration is sucked in through the breathing tubes into the lungs, which become inflated.

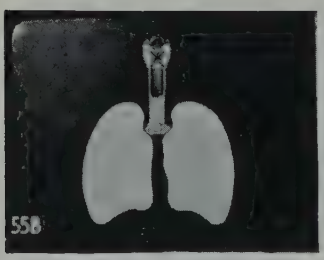
54-55. View of the *larynx* from above: In the center is the narrow opening of the larynx (*glottis*). To either side (along the black lines) are the *vocal cords.* In front, in an upright position, is the *epiglottis* (the lid for the larynx). The opening of the larynx is narrowed during expiration (See figs. 54, 55A) and widened during inspiration (See figs. 55, 55B) to allow the air to enter freely. *Voice sounds* are produced by the approximation and tension of the vocal cords, while the forceful currents of air during expiration cause them to

VOCAL CORDS, AND MECHANISM BY WHICH ARE PRODUCED VOICE SOUNDS AND RESPIRATORY RALES









vibrate. Should these vocal cords become inflamed, swollen or should some growth develop on them, preventing their proper approximation to each other, *hoarseness,* or even complete *loss of voice* may result.

55A-55B. Cross section of the larynx, trachea and the lungs. Note the narrowing of the opening of the larynx (glottis) by the vocal cords and the decrease in the size of lungs during expiration (55A) as compared to inspiration (55B).

56-62. The course of the air from the nostrils to the lungs. (As indicated on the body, pointing to the *level* of the *nasal passage* (57), *pharynx* (58), *larynx* (59), *trachea* (60), *bronchi* (61), *lungs* (62). (See fig. 20, p. 38.)

63. The entry and exit of air to and from the lungs is accompanied by *respiratory sounds* or *murmurs.* These sounds are characteristic, but may be modified by diseases of the lungs producing various abnormal sounds such as *râles* (rattling), harsh breathing, etc. By listening to the lungs (auscultation, see fig. 111, p. 93) the physician may recognize such conditions.

RESPIRATORY SOUNDS—RALES

When the trachea, bronchi, or lungs become inflamed as in bronchitis or pneumonia, their inner linings (mucous membrane) become swollen, secrete an excessive amount of mucus which may partly obstruct the flow of air, producing wheezing or rattling sounds (*râles*). It may also cause coughing spells, which are nature's effort to expel the mucus and clear the lungs and breathing tubes of foreign material.

66. Diagrammatic drawing of the *heart and blood vessels,* including those going to the lungs. (See fig. 24, p. 78.) The blue (*venous*) blood enters the lungs through the pulmonary arteries, takes up the oxygen from the lungs, and gives back its carbon dioxide to the lungs; thus it becomes of red (*arterial*) color, and is then returned back to the left side of the heart through the pulmonary veins. From the left side of the heart, the arterial or red blood is distributed to all parts and tissues of the body. The exchange in the lungs, by which the venous or blue blood becomes arterial or red blood, is termed *"external respiration,"* in contrast to *"internal respiration"* which is the exchange that takes

place between the arterial blood and the tissue cells of the body, where the cells take up the oxygen from the blood and give back the waste products (carbon dioxide) to the blood. (See figs. 87-98 and 103, 106, p. 90 and 91.)

The lungs continually remove the oxygen from the inhaled air, which enters the blood to combine with the food, producing energy (heat, growth, thought, action) by a process of oxidation, and continually expel from the body the resulting waste product, carbon dioxide (CO_2).

67. The air which we breathe and the atmosphere in which we live would soon be unfit were it not for the fact that the carbon dioxide and other waste products which we exhale are constantly replaced by the oxygen of the purified air which we inhale. This process of purification of the atmosphere is accomplished by natural forces:— The wind dilutes and sweeps away impurities and brings back pure air in their place. The rain washes the air, carrying down in its fall dissolved gases and suspended impurities. The green part of plants in sunlight absorbs the carbon dioxide (CO_2), retains the carbon, and sets free the oxygen.

This constant supply of fresh air which is so essential to life is attainable by the mere effort of proper ventilation. Fresh air and sunshine enable the breathing apparatus to keep the fire of life burning longer and brighter.

REEL 3—THE URINARY SYSTEM

Elimination of the Waste Products from the Body: It has been stated in the two preceding reels (The Digestive and the Respiratory Systems) that the blood is constantly supplied, by means of the respiratory and digestive mechanism, with all the chemical substances it requires to maintain the life, growth and activity of the body. The blood carries these substances to all the cells and tissues where they are transformed, by the process of oxidation, into energy. One of the results of these chemical combinations is the formation of waste products which must be removed from the body, as many of them are poisonous.

The waste products thus produced consist of soluble salts (urea and sodium chloride, etc.), water, carbon dioxide gas, etc. These together with the food residue are removed from the body as excreta (waste matter). The process by which they are removed is called *excretion* or *elimination.* The lungs eliminate the carbon dioxide and water; the skin eliminates (by means of the sweat glands) mostly water in the form of perspiration; the alimentary canal eliminates solid waste material. The urinary system, by means of the kidneys, eliminates a good deal of the water which holds in solution various substances such as urea, uric acid, etc.

The organs of the Urinary System consist of—*two kidneys, two ureters, one bladder,* and *one urethra.*

5-10. **The Urinary Organs**—as they appear in their relative normal position in the body: The two *kidneys* are situated one to either side of the spinal column at the posterior part of the abdominal wall (termed the lumbar region or loin). From the *aorta* to the left and the *vena cava* to the

THE URINARY ORGANS AS THEY APPEAR IN THE BODY

right of the midline, the renal arteries and veins, respectively, branch off at right angles to enter each kidney. (Figs. 5-6.)

The two ureters lead from the kidney downward and inward toward the midline to enter the bladder by two ureteral openings (orifices)—figs. 7-9). The bladder is in the center at the lower part of the abdomen. It has three openings; two

for the entrance of the ureters at the back, and one for the urethra in front (figs. 9-10).

The kidneys are two bean shaped organs which separate (secrete) and filter the waste matter (urine) from the blood. (See figs. 5, 12, 15.)

11A. Dissection of the heart and blood vessels of a newborn infant, including kidneys, ureters, etc. (For full description, see fig. 9, p. 57, and figs. 6-9, p. 72.)

12. Dissection of the adult female urinary and reproduc-

KIDNEYS, URETERS AND BLADDER—THEIR RELATION TO UTERUS, TUBES AND OVARIES

tive systems, including the *kidneys, ureters, bladder,* left *suprarenal gland, uterus, tubes, ovaries* and *round ligaments.* (See fig. 14, p. 97.) The organs are placed as they appear in their relative normal position in the body. The right kidney is somewhat lower than the left, due to the position of the liver on the right side.

The kidneys are about four inches long, two and one-half inches wide, and one and one-half inches thick. Each weighs about four and one-half ounces (a quarter of a pound). Each kidney has an upper and a lower pole, an inner and an outer border, an anterior and posterior surface. At the inner notched border (*hilus*), the renal vein, artery and ureter enter the kidney. (See fig. 15.)

The right and left *ureters* pass from the inner notched border (hilus of the kidney), downward and inward behind the spermatic or ovarian vessels underneath the tubes and ovaries, alongside of the uterus, to enter the posterior wall of the bladder. The *ovarian arteries* branch from the aorta, pass downward and outward and cross in front of the ureters at about their middle, to reach the tubes and ovaries, which they supply with blood. (See fig. 22, p. 54, and figs. 15-20, p. 98.)

Note: The *left* ovarian vein (or the left spermatic vein in the male) enters the *left renal* vein which in turn enters the inferior vena cava at right angles. The *right* ovarian vein enters directly into the inferior vena cava at an oblique angle. This accounts for the more frequent disturbances of the circulation on the left side, such as varicocele, etc., as compared to the right.

Below: *the uterus* is in the center above and behind the bladder; to either side of the uterus are the round ligaments in front, the Fallopian tubes in the middle, and the ovaries behind. The outer pole of each ovary is attached to the outer

fimbriated end of each tube by a ligament (the fimbrio ovarian ligament). A Malpighian body (a small cyst) is hanging from the fimbriated extremity of the left tube. Below and in front of the uterus is *the bladder.* The ureters pass along each side of the uterus and enter the posterior part of the bladder.

The kidneys are supplied with blood through the *renal arteries.* The blood is returned from the kidneys through the *renal veins* which enter the inferior vena cava at right angles. (See fig. 15.)

15. Dissection of the kidneys, ureters, aorta, vena cava and their branches:

The aorta and vena cava give off at right angles the *renal arteries and veins* respectively, which enter the inner border (hilus of each kidney). The *vena cava* is to the right of the *aorta.* The left renal vein is consequently longer and the left renal artery shorter. (See fig. 8, p. 72.) The renal veins are in front of the renal arteries, their relative position: the veins in front, the arteries in the middle, and the ureters behind (V. A. U.).

Note the *anomaly* (irregularity) in this case: Each kidney receives *two* renal arteries instead of one. The upper renal arteries are in this case in their normal position, behind and partly hidden by the renal veins. The lower anomalous (irregular) branches arise from either side of the aorta about two inches below the upper ones and pass upward and outward to enter the hilus near the lower pole of each kidney just behind the ureters. This lower anomalous artery may kink and compress the ureter, blocking the flow of urine from the

kidney, producing what is termed hydronephrosis (an overfilling of the kidney with fluid).

The *ureters* pass from the hilus of each kidney, downward and inward in front of the terminal branches of the abdominal aorta (iliac arteries) and pass alongside of the pelvis to enter the bladder. *The aorta and inferior vena cava* divide at their lower ends into their two terminal branches, the *common iliac arteries and veins,* which in turn subdivide about two inches further down into an *internal and external iliac artery or vein.*

Note: The *right common iliac artery crosses in front of and may press upon (compress) the left common iliac vein.* This accounts for the more frequent disturbances of the circulation of the left leg, such as varicose veins, or the occurrence of a swollen leg (milk leg, phlebitis) which sometimes follows confinement or operation. To the extreme lower left is the *inferior mesenteric artery* and its branches, which comes off from the aorta below the renal arteries to supply the lower part of the large intestine. The upper part of the large intestine and all of the small intestine are supplied by the superior mesenteric artery.

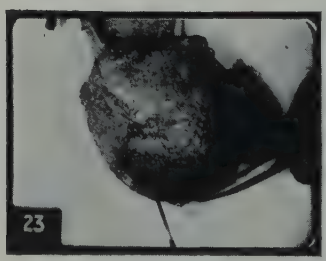
17. **Suprarenal Glands** are two small triangular shaped bodies resting upon the upper pole of each kidney. They are ductless glands furnishing an internal secretion (*adrenalin*) which helps to maintain the normal *blood-pressure.* Adrenalin, as obtained from animals, is used to control bleeding and combat shock when the pressure is too low. (Note the suprarenal gland on top of the left kidney. (See fig. 14, p. 97.)

19. **Ureters**—are the tubes which convey the urine from the kidneys to the bladder. (See figs. 5, 12, 22, and fig. 14, p. 97.) The upper portion which enters the kidney is called the *pelvis.* The ureter is about ten to twelve inches long, the diameter of a goose quill.

KIDNEY STONES—INFLAMMATION OF THE KIDNEYS AND BLADDER

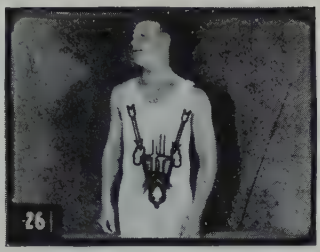
Should some of the soluble substances in the urine *precipitate* (become solid), a condition which generally results from bacterial infection or disturbed metabolism, *calculi* (kidney stones) may form in the kidney. Should one of these small stones drop into the narrow lumen (canal) of the ureter it may block the flow of urine from the kidneys into the bladder, producing severe colicky pain, distention (*hydronephrosis*), and even rupture the kidney, with abscess formation. Inflammation of the kidneys and bladder may likewise result. When the kidneys become inflamed from various causes, such as mentioned above, their function becomes impaired and may, as a result, allow some of the albumin from the blood to pass into the urine. Part of the lining (epithelium) of the kidney tubules may disintegrate and allow the escape of red and white blood cells, which together form various casts (moulds), pus, etc. Albumin, casts or blood cells, when present in the urine, suggest a diseased condition of the urinary tract, especially the kidneys.

21. **The Bladder** is a reservoir for the urine. Note the bladder below indicated by the pointer. (See figs. 5, 12, 22.)



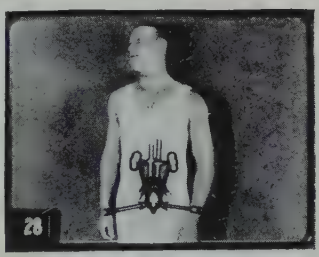
22-23. *The bladder and ureters* viewed from above: The average capacity of the bladder is about one pint. Note: The ureters above, to either side of the uterus, enter the muscle wall of the bladder at an *oblique angle*. Such an angle produces a *valve-like* ar-

rangement by which urine may pass from the ureters into the bladder, but is prevented from flowing back into the ureters.



23. The Bladder and Ureters viewed from the right side: The *urethra* is a canal through which urine passes from the bladder to the outside. It is situated at the lower front portion of the bladder (as indicated by the forceps and metal sound).

25. *The urine—is excreted* from the blood *by the kidneys.* It *passes to* the *ureters*—then to the *bladder* —to the *urethra*—to the outside. The average amount passed in twenty-four hours is about one and one-half quarts. The amount varies; it is increased in certain diseases such as diabetes, nervous conditions, etc., and with the taking of an excessive amount of liquid. The quantity is diminished during excessive perspiration, fever, kidney trouble, etc., or when an insufficient amount of liquid is taken into the body.



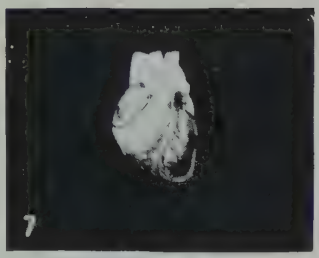
26-29. Diagrammatic presentation of the course taken by the urine through the urinary-tract: The urine is excreted by the kidneys from the blood (fig. 26). It

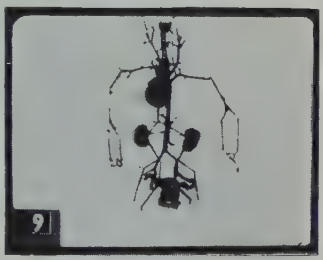
WATER AS THE VEHICLE FOR THE ELIMINATION OF BODY WASTE

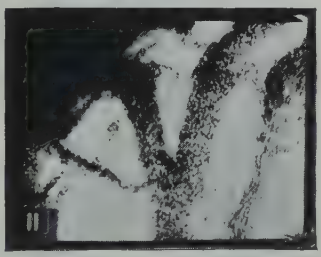
passes through the ureters (fig. 27) into the bladder (fig. 28) from there passing through the urethra to the outside (fig. 29).

30-31. Water furnishes the medium for the urine in which the soluble waste products and poisonous material (urea, uric acid, etc.) are carried away from the blood. Various liquid ingredients (soluble substances) affect the system differently. Strong drinks containing alcohol irritate and may injure the kidneys. Pure water flushes the system and enables the kidneys to remove the poisonous material from the body properly. Such elimination of waste matter is vital to good health.

REEL 4—THE CIRCULATORY SYSTEM: THE HEART AND HOW IT WORKS







The Vascular System consists of: (1) The *blood:* a circulating fluid which carries nourishment to all the tissues of the body and carries back their waste material; (2) The *heart:* which propels the blood to all parts of the body; (3) The *blood-vessels:* a system of elastic tubes through which the blood is conveyed to and from all the tissues of the body. (Figs. 7, 9, 11.)

7. *The heart* is a ceaseless motor, propelling the blood through the blood-vessels, to all parts of the body. The lower pointed portion is the *apex,* the upper wider portion is the *base* of the heart, from which spring the main blood-vessels. To the right and above is the *right auricle;* below is the *right ventricle.* To the left and above is the *left auricle;* below, reaching down to the apex, is the *left ventricle.*

Frame 9. **Dissection of the vascular system** of a newborn infant, including trachea (wind-pipe), kidneys, ureters, uterus, tubes and ovaries, placed in their relative normal position as they appear in the body: In the midline above is the larynx and trachea (wind-pipe). To either side are the

carotid arteries and their branches. Below, to either side are the *arteries* of the *arms, forearms and hands.* In the center is the *heart* with the main blood-vessels leading from it, the *aorta* and the *vena cava.* Below the heart are the branches of the aorta going to the abdominal organs, including the *kidneys* which are placed to either side. The aorta divides at its lower end into two terminal branches, the *iliac arteries.* The *ureters* pass from each kidney towards the bladder, cross in front of the iliac arteries and pass alongside of the uterus. At the lower part, in the center, is the *uterus* with the *tubes, ovaries* and *round ligaments* to either side.

11. The actual *flow of the blood through the blood-vessels, as seen through a microscope:* At the center is an artery with two branches filled with blood. The blood corpuscles appear distinct. To the extreme end is a vein with its branches. In the arteries the flow of blood rhythmically increases with every contraction (systole) of the heart. (See fig. 106, p. 91.) In the veins the blood flows in a constant stream.

13-15. The heart lies in the chest cavity surrounded by the lungs. (See figs. 22, 23, 26, pp. 40, 41.)

14. The anterior chest wall and part of the pericardial sac are removed to show the *heart in the center,* with the *lungs to either side.* (See fig. 23, p. 41.) Its apex points forward and to the left. Its lower posterior surface rests on the diaphragm. To either side of the heart is the remaining part of the pericardium which encloses the heart in a separate compartment and separates it from the lungs. The *pericardium* is attached below to the diaphragm and above to the roots of the blood-vessels springing from the base of the heart. To either side of the pericardial sac are the inner concave surfaces of the right and left lungs which are held

INTERIOR VIEW OF THE CHEST: THE HEART, LUNGS, PERICARDIUM AND DIAPHRAGM

apart to show their anterior borders and the roots of the lungs (hilus) where the bronchi and blood vessels enter.

15. **The lungs** are inflated (by the Pneumo-Viscera Method) simulating inspiration. (See fig. 26, p. 41.) *They partly surround and cover the heart.* They are mottled dark due to the inhalation of coal-dust, etc., which accumulates

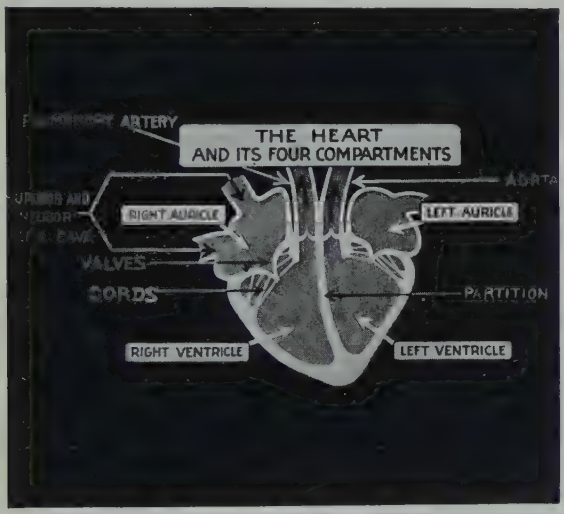


FIG. 18

during the course of life. The base of each lung and the lower posterior surface of the heart rest upon the dome of the diaphragm, which separates them from the abdominal organs. When the stomach becomes overfilled with food or gases it may force the diaphragm upward pressing on the heart and lungs, causing great distress in the form of palpitation and shortness of breath. (See figs. 37-38, p. 30.)

17. Diagrammatic view of the *four chambers* of the *heart,* together with the valves, the veins which enter the upper

THE HEART: ITS CHAMBERS, PARTITIONS, VALVES AND CORDS

chambers (auricles) and the arteries which leave the lower chambers (ventricles) of the heart.

18. **The heart and its four compartments:** The right side of the heart is separated from the left by a partition (*septum*) between the auricles and ventricles. Each auricle is separated from each ventricle by a set of valves (*auriculo-ventricular valves*). These are steadied by cords (*chordae tendineae*) which originate from elevations (*papillae*) of the muscles of the wall of the heart and are attached to the under surface of the valves. A set of smaller valves (*semilunar valves*) separate the right ventricle and the left ventricle from the pulmonary artery and the aorta, respectively.

20. **Dissection of the heart,** viewed from the right side. The opening of the *aorta* is above and to the right. Below is the interior of the *right auricle.* Above and to the left is the beginning of the *pulmonary artery,* and below is the interior of the *right ventricle.*

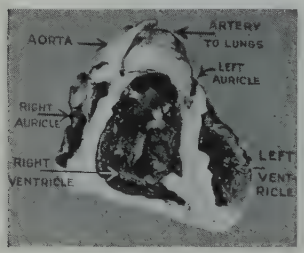
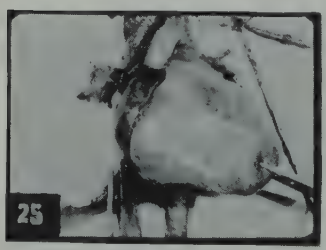


FIG. 20



22. *Anterior view of the heart:* Above is the beginning of the pulmonary artery. The coronary artery lies over the ventricular septum (partition) which separates the right from the left ventricle. (See fig. 83, p. 88.)

23. The right auricle is separated from the right ventricle by the valve (*tricuspid valve*) which is attached to the fibrous ring between the two chambers. (See fig. 60, p. 63.)

25. **An exterior view of the heart,** together with the main

blood vessels leading from it: (The size of the heart of any individual is approximately equal to the size of his closed fist.) Above is the superior *vena cava;* behind and to the right are the branches of the pulmonary artery and veins; to its left, the *arch* of the *aorta* and branches of the left pulmonary artery and veins; below and to the left is the right ventricle. The lower extreme left part of the heart (the *apex*) consists mainly of the left ventricle. Below the heart is the *inferior vena cava* with the *hepatic veins* and the *aorta.* To the left is the *thoracic duct* with its cisterna chyli.

26. The *superior vena cava* leads into the *right auricle* from above. (A probe is seen entering through into the right auricle.) (See fig. 72, p. 85.) In the center is the interior of the *right ventricle.* To the extreme left is the *apex* with part of the *left ventricle.*

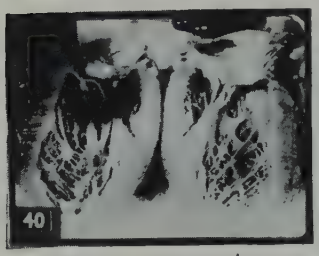
30. Exterior view of the left side of the heart showing the pulmonary veins entering the left auricle, all of the *left ventricle,* with the anterior branches of the left *coronary artery* (artery supplying the heart muscle). To the left and above is the thoracic duct entering the subclavian vein, near the part where it joins the jugular vein.

31. Interior of the *left auricle* viewed from behind and above: Above is the *pulmonary artery* dividing into its right and left branches. Below is the interior of the left auricle with the auricular septum which separates the left auricle from the right. (See figs. 39, p. 79, and 81 p. 87.)

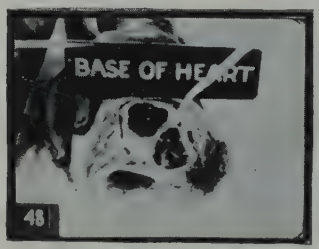
33. Interior of the left ventricle: To the right is the ventricular septum and the muscle bundles (columnae carneae). To the left are two muscular papillae with the tendinous cords attached above to the mitral valves. (See fig. 41, p. 79.)

35, 37. The auricles are the upper chambers of the heart; the ventricles are the lower. (See fig. 18, p. 59.)

THE PARTITION BETWEEN THE VENTRICLES—THE FOUR OPENINGS AT THE BASE OF THE HEART



P. A.



40. A vertical section of the heart showing the interior of the divided halves: (P. the posterior, A. the anterior half). P.—The posterior part of the *left auricle* is above. Extending down are the *mitral valves* with the *chordae tendineae* attached below to the *muscular papillae* which fuse with the muscle of the heart wall. A network of muscle bundles (the *columnae carneae*) and the thick *ventricular septum* are below and to the right. The anterior half (A) shows the anterior portion of the left auricle, the chordae tendineae, muscular papillae, the columnae carneae and the ventricular septum.

41. Cross section of the heart. The *apex* is being removed.

42-45. Cross sections of the heart showing the partition (*ventricular septum*) separating the right from the left ventricle.

46. The artery supplying the heart (the anterior branch of the left coronary artery) is on the partition which separates the right from the left ventricle. (See fig. 74, p. 85.)

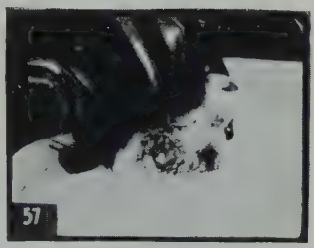
48. **The base of the heart** viewed from above and behind, showing the *four rings* (openings). The *pulmonary* opening is in front and to the left; the *aortic* is behind and to the

right; the *tricuspid* is behind and to the right; the *mitral* opening is behind and to the left.

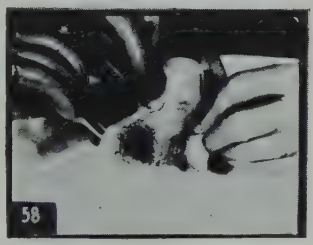
50. The opening of the pulmonary artery is anterior and to the left (indicated by pointer).

52. The aortic opening is guarded by *three semilunar valves.* (One is lifted up by the forceps.)

53. A view of the aorta from above looking towards the semilunar valves.

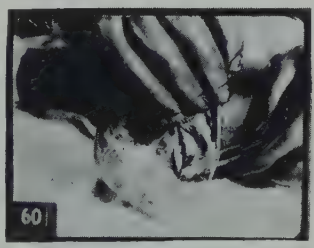


56. **The mitral valve**—between the left auricle and ventricle, has *two* flaps or *cusps.* Mitral cusps are held apart by forceps (fig. 58) to show the ring (opening) leading from the left auricle to the ventricle. (The openings between the auricles and ventricles are viewed from behind and above. The upper portions of both auricles are removed to show the aorta in the center with the mitral valve to the left and tricuspid to the right.)



57. **The mitral cusps** (flaps) are brought together closing the ring (opening) between the left auricle and ventricle. 58. Same as 56.

60. **The tricuspid valve** has *three cusps* or flaps. Note to the left, the mitral opening with its two cusps.



61. A diagrammatic cross section of the heart: Note: There are valves between the auricles and ventricles and

ANALOGY BETWEEN THE VALVES OF THE HEART AND THAT OF A SYRINGE

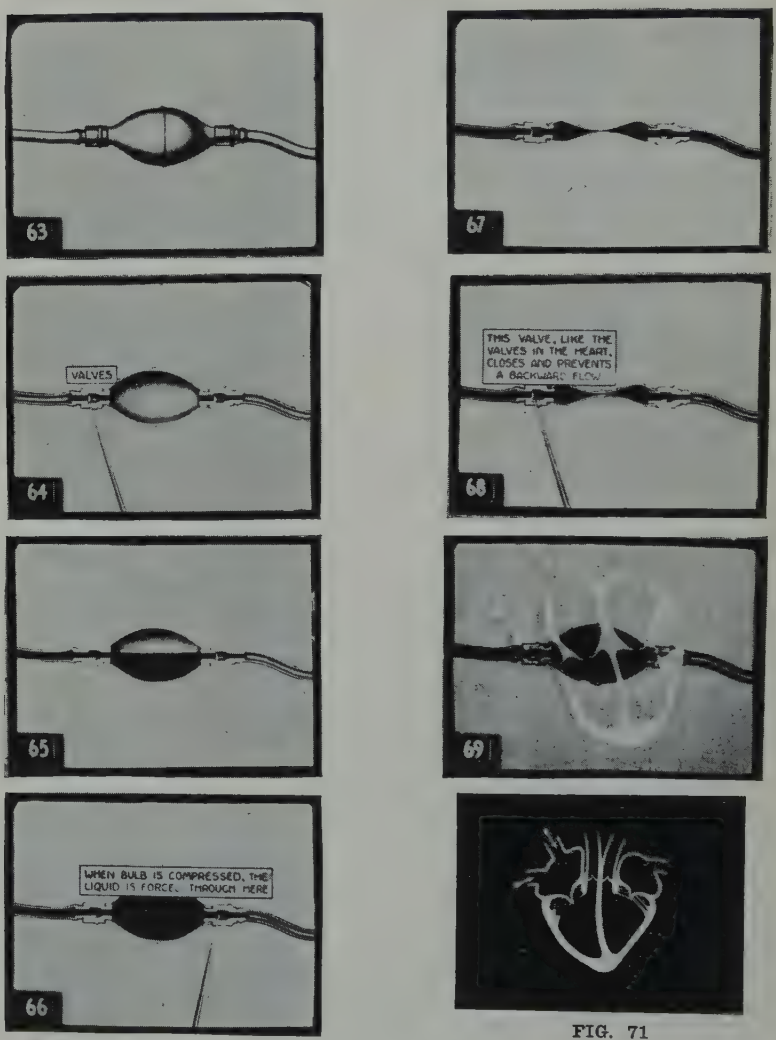


FIG. 71

between the ventricles and arteries leaving the heart, but there are no valves between the veins and the auricles which they enter. (See fig. 18, p. 59.)

THE ONE WAY ACTION OF THE HEART VALVES

63-69. A double exposure, with cross sections of a syringe and the heart chambers to carry out the *analogy* between the action of the *valves* of the *heart* and that of a *syringe.*

FIG. 72

70-74. **The one way action of the valves:**

71. **Course of blood through the heart:** The blood from the veins (superior and inferior *vena cava* and *pulmonary veins*) enters and fills the upper chambers, the *auricles.*

FIG. 73

NOTE: To avoid confusion, only the course of the blood flow in the right side of the heart is illustrated here; a similar flow takes place in the left chambers of the heart.

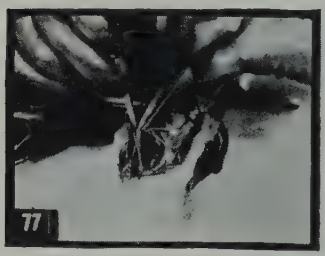
72. The auricles then contract causing their auriculo-ventricular valves to open widely and allow all the blood to pass into and fill the *ventricles.*

FIG. 74

73. Then the ventricles contract, causing the above valves to close tightly, thus preventing the blood from flowing backward—

74. —and force open the valves leading to the main arteries (*aorta* and *pulmonary artery*) to allow the blood to pass to *all parts of the body.* The semilunar valves of the aorta and pulmonary artery

FIG. 74 A



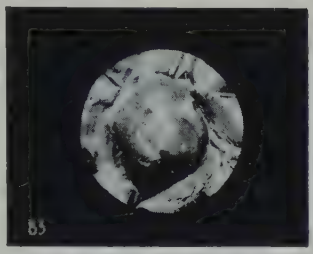
then close to prevent the blood from flowing back (regurgitate) into the ventricles. (Fig. 74A.)

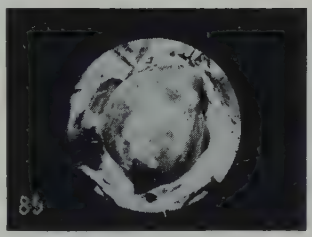
76-78. **The valves and their tendinous cords:**

76. An interior view of the *right ventricle.* The *tricuspid valve* is held on a stretch (by a probe). Above is one of its cusps (flaps) from the lower free end of which are stretched the *tendinous cords* (resembling a sail) which attach themselves below to the muscle bundles (*muscular papillae*) of the heart wall.

77. The cusps are approximated (held together) as during systole, when the ventricles contract, to prevent the blood from flowing back into the auricles.

78. **Leaking Valves and Heart Murmurs:** The flaps are kept apart during the contraction of the auricles, to allow the blood to pass into the ventricles. These valves, due to diseases such as rheumatism, tonsillitis, abscessed teeth, etc., may become inflamed, roughened and puckered up. As a result of such inflammation, the valves may cause a narrowing of the openings between the auricles and ventricles and may not fit tightly during their closure; thus at times partly obstructing the flow of the blood in the *proper* direction (*stenosis*) and at other times allowing the blood to flow back (*regurgitation*) in the *wrong* direction. This results in what





is termed *leaking* (incompetent) *valves,* and as the blood passes to and fro it produces purring sounds called *murmurs.*

80. **The heart-beat** consists of a coordinated contraction of the heart muscle resulting in the expulsion of blood from both ventricles. It is divided into two phases, (1) *systole* and (2) *diastole.*

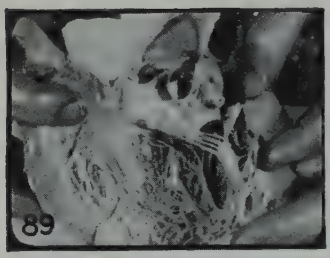
83. **Systole** is the period of the contraction of the heart muscle.

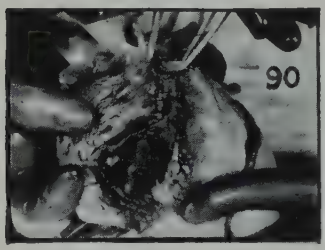
A living heart in action:* The heart in the center, is seen during its contraction (*systole*). As the heart contracts it strikes the left side of the anterior chest wall to which the impulse is transmitted (*apex beat*) where it may be seen, felt and heard. During its contraction the heart becomes much smaller, firmer and rounder, the apex approaching the base. With every contraction (systole), the heart expels (pumps) about three ounces of blood from each ventricle, which enters into the main blood vessels. During systole the heart is much smaller than during diastole, as illustrated in the next scene.

85. **Diastole** is the phase of relaxation of the heart muscle and the filling of the heart chambers. As the heart fills with blood it becomes much larger, more elongated. The apex is further away from the base, becomes softer, and lies flat against the chest wall. During diastole about three ounces of blood flows from the veins into each auricle and then into each ventricle.

* With the aid of slow motion pictures of the mammalian heart action from which these scenes are taken, the various phases of the heart-beat can distinctly be observed.

INTERIOR OF THE HEART





89. **An interior view of the left auricle and left ventricle:** The walls of the heart are composed of strong *involuntary muscle tissue* (muscle whose action is not under control of the will) much thicker at the ventricles than at the auricles. These are held apart to show: above to the left, the left auricle, below, the left ventricle with its mitral valve, the chordae tendineae and the muscular papillae. Above and to the right is the upper part of the left ventricle leading towards the aorta with its three semilunar valves. The muscle wall of the left ventricle is much thicker than the right ventricle, as illustrated in the next scene.

90. **An interior view of the right auricle and ventricle.** The walls of the heart are held apart to show: The right auricle above to the right partly hidden from view by the auriculo-ventricular septum. Below to the right is the tricuspid opening with its valves consisting of three cusps (as indicated by the tip of the finger which passes from above through the opening). To the left and above is the upper portion of the right ventricle leading toward the pulmonary artery, with its semilunar valves (held by forceps). To the left of this interior view is the exterior of the left ventricle.

92. **Heart Sounds:** Listening to the heart by means of a stethoscope. (See fig. 111, p. 93.) Various sounds are produced by the contraction of the heart muscle, the closure of the valves, and the flow of the blood through its openings and chambers. The two typical heart sounds are similar to

the pronunciation of the words *lŭbb dŭb*. By listening to the heart a physician is able to tell the rate and force of the heart action and the condition of its valves as evidenced by the presence of various sounds called murmurs. When the valves are diseased and roughened, as the blood flows by, various abnormal sounds (*murmurs*) are produced.

The work of the heart: (See fig. 7, page 57, and fig. 111, page 93.) To gain an idea of the amount of work which the heart performs, it would be well to observe the following figures. Each ventricle holds about three ounces of blood. With each systole of the ventricles, that amount of blood is forced into the pulmonary artery from the right ventricle, and into the aorta from the left ventricle. The heart beats about seventy-two times a minute. The average human body (weighing 140 pounds) holds about one hundred and fifty-five ounces or five quarts of blood, being 1/13 of the body weight. It takes the heart about twenty-eight beats or twenty-three seconds to pump its blood (five quarts) through its chambers to all parts of the body, before it returns to the heart. The ventricles therefore pump one and a quarter gallons of blood every twenty-three seconds, which is approximately 3 gallons a minute, 180 gallons an hour, 4,320 a day, 1,576,800 a year. Its work is equivalent to lifting daily about ten tons to a height of about five feet.

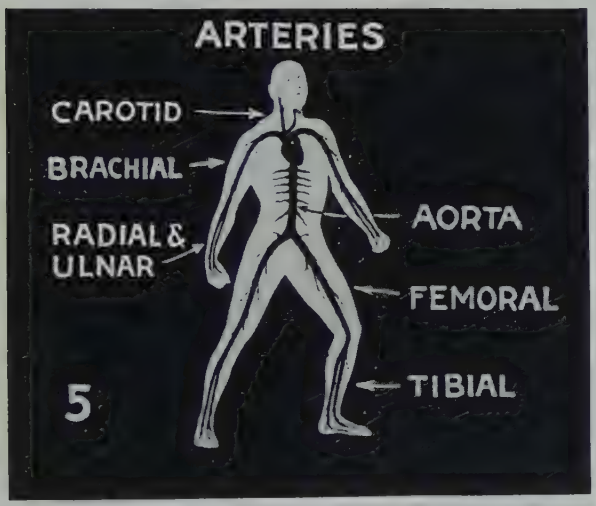
The heart with its intricate construction of chambers, partitions, valves, cords and muscle bundles is controlled by a delicate mechanism of nerve fibers. These convey the impulses which maintain the heart unceasingly at work from beginning of life to its end. An engine of such small size subjected to frequent effort and strain, propelling a million and a half gallons of blood yearly to all parts of the body, certainly merits proper consideration. Well regulated exercise, with

the avoidance of too strenuous efforts which might overtax its endurance, will aid in keeping the Human Engine in perfect running order, and may offset many a disturbance or breakdown.

REEL 5—THE CIRCULATORY SYSTEM: BLOOD-VESSELS AND THEIR FUNCTION

The blood-vessels form a system of elastic tubes, in which throughout life there is a ceaseless movement of blood.

5. **Diagrammatic drawing of the heart and blood vessels, as they appear in their relative position in the body:** The main blood-vessels spring from the heart, from which they



THE AORTA AND ITS MAIN BRANCHES

emerge to branch and lead to all parts of the body. From the heart (in the center of the chest) the main artery, the aorta, arises. It gives off: the *innominate* and *carotid* arteries leading to the head and neck; the *subclavian* arteries leading to the arms (*brachial*), to the forearms and hands (*radial* and *ulnar*). The radial and ulnar arteries go to the outer and inner sides

of the forearm respectively, and reach the hand to form the *superficial* and *deep palmar arches* to supply the hand and fingers. (See fig. 47, front page.)

In the thorax, the aorta (*thoracic aorta*) gives off on each side the *intercostal* arteries passing along under each rib to supply the chest. In the abdomen, the (*abdominal*) *aorta* gives off branches to supply the abdominal walls and abdominal organs.

At the lower part of the abdomen (at about the level of the fourth lumbar vertebra), the aorta divides into its two terminal branches, the *common iliac* arteries. These supply the organs of the pelvis and pass down to each lower limb, termed the *femoral* artery in the thigh, *popliteal* artery behind the bend of the knee. The popliteal artery divides into the *tibial* and *peroneal* arteries which go to the inner and outer side of the leg. These terminate in branches as, the *dorsalis pedis* on top of the foot, and the *plantar* arteries, at the sole of the foot, which supply the foot and toes.

6-9. **Dissection of the heart and blood-vessels:** The vascular tree of a newborn baby girl, including the trachea,

kidneys, ureters, uterus, tubes and ovaries. The parts are placed as they appear in their relative normal position in the body.*

6. **The carotid arteries and their branches:** In the midline above is the larynx, with the trachea below. To either side are the right and left carotid arteries and their branches, such as the superior thyroid, lingual, facial, superficial temporal arteries, etc.

Note: Between the trachea and the carotid, on each side, are the *vertebral arteries* which go through the vertebral foraminae (openings) to reach the brain.

7. **The heart, aorta and its main branches:** (This scene is a continuation of figure 6). *The heart* is in the center—its thin upper collapsed portion consists of the *auricles.* Its lower firm and rounded portion consists of the *ventricles.* The two innominate veins which receive the blood from the head and upper limbs join to form the superior *vena cava* which passes down from above, and enters into the *right auricle.*

To the right and behind the vena cava, above the heart, is the *innominate artery.* It springs from the arch of the aorta, and divides into the *right common carotid,* passing upward to the neck, and the *right subclavian* artery, passing outward to the right shoulder and arm.

The *thyroid axis* and *vertebral artery* spring from the first portion of each subclavian artery and go upward towards the head and neck. The *left carotid and subclavian* arteries spring directly from the arch of the aorta, there being only one innominate artery (the right one). The *arch of the aorta*

* Note the similarity between the diagrammatic drawing (fig. 5, page 71) and the actual dissection in figs. 6-9. To avoid confusion, the entire arterial tree with only a few of the large veins, such as the vena cava and renal veins, is shown in this dissection. The other corresponding veins which run parallel to the arteries are omitted. (For a complete view of the same scenes see figure 47 on front page.)

ARTERIES OF THE THORAX AND ABDOMEN

descends to the left and behind the heart, there becoming the *thoracic aorta.* To the right, behind and below the heart, is the inferior vena cava.

8. **The abdominal aorta** and its branches, including the inferior vena cava, kidneys and ureters: (This scene is a continuation of figure 7.) The abdominal aorta is to the left of the midline. It gives off above, the *celiac artery* with its three branches: (1) *Hepatic artery,* leading upward to the right to supply the liver;—(2) *Gastric artery,* leading upward to the left to supply the stomach;—(3) *Splenic artery,* leading horizontally towards the left to supply the spleen, etc.

Below the celiac artery, the *superior mesenteric artery* comes off to supply the small and upper portion of the large intestine. To either side, at the same level, are the two *renal arteries,* one going to each kidney. The blood from each kidney situated on either side, is returned through the renal veins to the inferior vena cava.

Note.—The left *renal vein* is *longer* than the right. The left *renal artery* is *shorter* than the right. This is explained by the position of the aorta which is to the left, and the vena cava which is to the right of the midline.

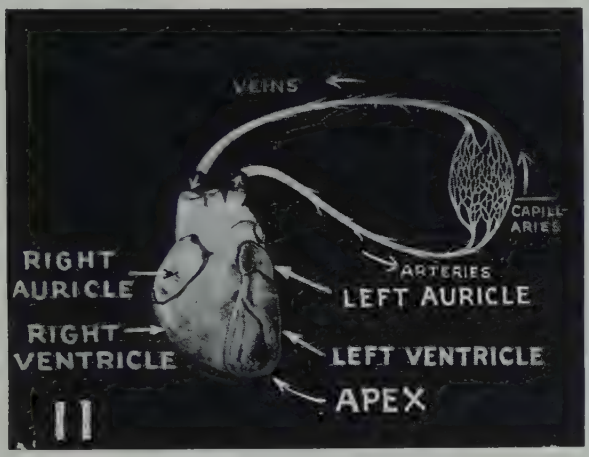
Below the renal arteries is the *inferior mesenteric artery* supplying the lower part of the large intestine. The lower part of the aorta divides into its two terminal branches, the right and left *common iliac arteries.* In the center (tail-like), is the *middle sacral artery.* The *ureters* which pass from the kidneys downward and inward, cross in front of the iliac arteries on their way down to enter the bladder.

9. The iliac arteries divide into an external and internal branch. The *external iliacs* pass downward and outward to supply the lower limbs (these are the outermost in this figure). The *internal iliac arteries* pass down to supply the pelvic organs, such as the uterus, bladder, etc.

COURSE OF THE FLOW OF BLOOD

Note—*The uterus* is in the center of the pelvis. To either side are the ovaries, tubes and round ligaments. The *uterine arteries* branch from the internal iliac arteries and pass along the uterus and vaginal canal to supply them with blood.

11-15. **Course (cycle) of the flow of blood:** The *heart* pumps the blood into the *arteries*—the blood passes from the *arteries* into a network of fine tubes called *capillaries*—from



the capillaries the blood passes into the *veins,* back to the *heart.* (See fig. 11.)

11. Diagrammatic drawing of the *heart* with a *vascular loop* consisting of an artery, a capillary network and a vein: The arteries lead from the heart, terminate in capillaries which collect into veins leading back to the heart. The blood passing to and from the left side of the heart is arterial blood; the right side of the heart, venous blood.

13. From the arteries, the blood enters the capillaries. From the capillaries the arterial blood enters all tissues of the

body to supply them with nourishment (fuel).* The blood then takes back from the tissues, the waste products such as carbon dioxide, becomes venous (blue in color) and passes through the veins (fig. 14) back to the right side of the heart (fig. 15) and from there goes to the lungs. (See figs. 87-98, p. 90.)

17. Arteries (diagrammatic version) are the elastic tubes in which the blood flows from the heart to all parts of the body. (See fig. 11, p. 57, and fig. 106, p. 91.)

19-36. **Course of arterial blood** (aerated red blood)—(Diagrammatic): Arterial blood passes from the *lungs* through the four *pulmonary veins* which enter the *left auricle.* From there it passes through the *left ventricle* to the *aorta,* to be distributed, through its branches, *to all parts of the body.* (See figs. 19-22.)

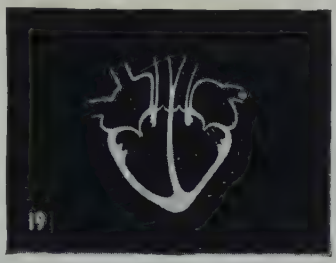
19. Diagrammatic drawing of the heart—showing the four chambers, partitions, valves, cords, veins entering, and the arteries leaving, the heart: (See fig. 18, p. 59.) In the center is a partition (septum) separating the right side (chamber) of the heart from the left side. To the right and above is the right auricle into which enter the superior and inferior vena cava. Below the auricle is the right ventricle, separated by the valve (tricuspid valve). To the left of this valve are the semilunar valves which lead from the right ventricle into the aorta. To the left and above is the left auricle. (A drop representing the blood flow is entering through the pulmonary vein.) Below is the left ventricle separated by the valve (mitral valve). To the right of the mitral valve are the

* Nourishment is obtained by the blood from the food in the intestines; the oxygen is obtained from the lungs. This oxygen combines with the food, in the process of oxidation, to produce energy.

COURSE OF ARTERIAL BLOOD THROUGH THE HEART

semilunar valves leading to the pulmonary artery.

19-20. The blood enters from the *pulmonary vein* into the *left auricle.*



21. The mitral valve opens and the blood passes through to the *left ventricle*—

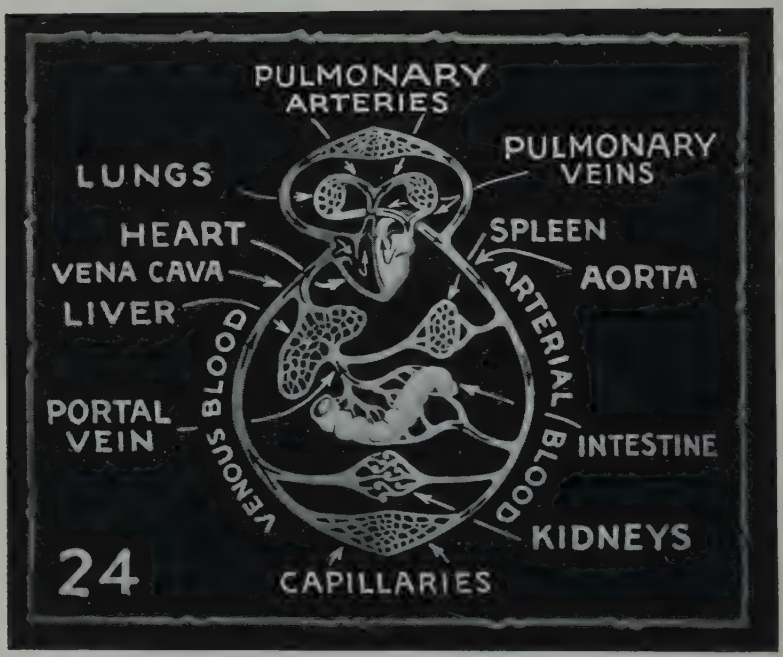
22. The mitral valve closes—the semilunar valves open and the blood enters the *aorta.* The semilunar valves then close to prevent the blood from flowing back (regurgitating) into the ventricle.

24. Diagrammatic drawing of the heart and blood-vessels and the course taken by the blood as it passes to all parts of the body. (Figs. 24-36.) (The left lighter side represents the left chambers of the heart and the blood-vessels through which *arterial* blood passes. The *right* darker side represents the right chambers of the heart and the blood-vessels through which *venous* blood passes.)

25-36. The blood passes from the *lungs* on each side, through the *pulmonary veins* into the *left auricle,* to the *left ventricle,* then

COURSE OF THE ARTERIAL BLOOD THROUGH THE BODY

to the *aorta*—to be distributed through its *branches* to all parts of the *body* such as the head and upper extremities—to the thorax and abdomen and their internal organs such as the spleen—liver—intestines—kidneys and lower extremities.



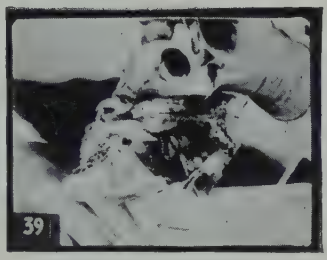
26. Note: The pulmonary veins are the only veins carrying arterial blood while the pulmonary arteries are the only arteries carrying venous blood. (Figs. 59-60.)

39-44. The course of the arterial blood as indicated in an actual dissection of the heart. (Illustrated by the passage of a curved metal sound.)

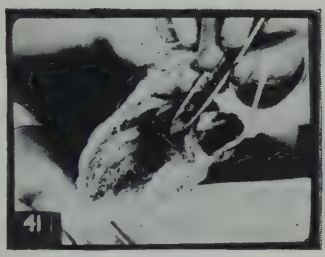
39. Dissection of the heart: The blood passes through the pulmonary veins into the left auricle. (Note the thin walls of the auricle.)

COURSE OF ARTERIAL BLOOD THROUGH THE HEART

41. From the left auricle it passes through the opening (auriculo-ventricular opening) into the left ventricle. (Note the thick muscle wall of the ventricle, as compared to the auricle, especially near the apex.)



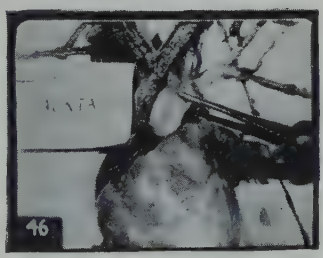
43-44. From the left ventricle the blood passes into the aorta. The aorta is about one inch in diameter. Its walls have almost the thickness of a garden hose.



46-48. Through the main artery, the aorta, the blood passes from the heart to all parts of the body.

46. Dissection of the heart and the blood-vessels leading from it: To the right and above (of a dark color) are the two *innominate veins* leading into the superior *vena cava,* which empties into the *right auricle.* To the left of the superior vena cava is the *arch* of the aorta giving off to the head and upper limbs its three large branches. Note: The aorta appears lighter, thicker and firmer than the vena cava.

The *right innominate* artery is the first large branch coming off from the upper convex surface of the aorta. It is partly covered in



front by the vena cava. The *left common carotid* and *subclavian* arteries are the two other large branches of the arch of the aorta. They lead to the left side of the head, neck and left upper limb. The *pulmonary artery* arises from the upper portion of the right ventricle (*conus arteriosus*), lies to the left and in front of the first portion of the aorta. The *left auricle* is below and to the left of the pulmonary artery while the *right auricle* is to the right and in front of the aorta and superior vena cava. To the extreme left is the long lymph duct (*thoracic duct*), ascending from the abdomen to enter into the subclavian vein.

47-48. Dissection of the heart and blood-vessels of a newborn infant: (For full description see figs. 6-9, pp. 72-75.) In addition, observe here the arteries of the upper limbs: that is, *subclavian*—to shoulder, *brachial*—to the arms, dividing into an outer (*radial*) and to inner (*ulnar*) artery, to supply the forearm. The radial and ulnar arteries communicate (anastomose) below, to form the superficial and the deep *palmar arches* which give off branches to supply the hand and fingers.

THE VEINS

50. **Veins** (diagrammatic) are the tubes in which the blood flows in a constant stream from all parts of the body back to the heart. (See fig. 11, p. 57.)

57-76. *The superior vena cava* conducts the blood from the upper part of the body; *the inferior vena cava,* from the lower part of the body, into the *right auricle.* From the right auricle it passes to the *right ventricle*—then to the *pulmonary artery,* which conveys the venous blood to the *lungs* to become arterial and return back to the *heart* through the pulmonary veins, which carry arterial blood. (See fig. 24, p. 78.)

THE PORTAL SYSTEM—COURSE OF VENOUS BLOOD THROUGH THE HEART

53. Diagrammatic drawing of the heart and blood-vessels (as described in fig. 24, p. 78.) The venous blood returns to the right side of the heart by the superior and inferior vena cava.

56. The venous blood coming from the capillaries of the digestive tract, that is the stomach, intestines, and also from the spleen and pancreas, does not enter directly into the vena cava. It first passes through a system of veins (*portal system*) which unite to form the portal vein. (See fig. 24, p. 78.) From the portal vein the blood passes to another set of capillaries in the *liver,* from which it passes through the *hepatic veins* (veins from the liver) into the *inferior vena cava. The blood from the digestive organs and spleen therefore passes through two separate sets of capillaries* before it reaches the heart. (See fig. 24, p. 78.)

62-64. Course of blood through the right side of heart: (For description of diagrammatic drawing of the heart, see fig. 18, p. 59.)

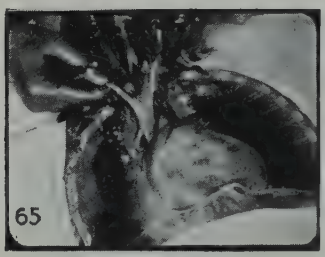
62. Venous blood enters through the superior and inferior *vena cava* into the *right auricle.*

63. The valve (tricuspid valve) opens and the blood passes into the *right ventricle.*

64. The tricuspid valve closes,

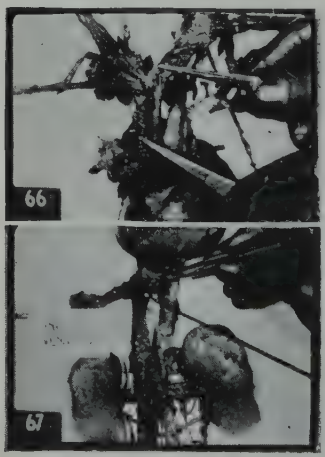
INTERIOR VIEW OF CHEST: HEART—VENA CAVA—DIAPHRAGM

the semilunar valves open, and the blood passes into the *pulmonary artery*. The semilunar valves then close to prevent the blood from flowing back (regurgitating) into the ventricle.



65. An interior view of the chest: The *heart* is in the center space (*mediastinum*). It is cone-shaped with its apex pointing downward and to the left; its *base*, with the main blood-vessels pointing upward and to the right. The heart rests below on the *dome of the diaphragm*. The *superior vena cava*, with its two innominate veins, enters the *right auricle* above and to the right. Above, in the midline, is the trachea. (It is opened to show the interior.)

To either side of the heart is the right and left chest cavity (*pleural cavity*) covered by the smooth lining of *pleura* (parietal pleura) through which may be seen the *ribs* comprising the greater part of the firm chest wall. The two lungs occupy the right and left pleural cavity, partly surround and cover the heart. (See figs. 22, 23, 26, pp. 40, 41.) The diaphragm below forms the floor (base) of the chest cavity. The upper ribs above form the dome of the chest cavity.



66. **The blood-vessels emerging from the base of the heart:** The right and left *innominate veins* unite to form the *superior vena cava* which enters above and

THE INFERIOR VENA CAVA—ABDOMINAL AORTA—THE ARTERIES AND VEINS OF THE KIDNEYS

to the right auricle. The *aorta* is to the left of the vena cava. It passes from the left ventricle upward and to the left, forming the *arch* of the *aorta,* giving off its three large arteries: the *right innominate,* the *left common carotid,* and the *left subclavian.* The *pulmonary artery* is below and to the left of the aorta. It passes from the right ventricle upward, backward and to the left where it divides, behind the ascending aorta, into a right and left pulmonary artery. (Fig. 81, p. 87.) Branches of the right pulmonary artery are seen behind and to the right of the superior vena cava. The *thoracic duct* passes upward and to the left and enters the left subclavian vein near the point where it joins the jugular vein. (See figs. 46, 76, 79, 81.)

67-68. **Inferior vena cava, aorta, and their abdominal branches,** including the *kidneys and ureters:* The inferior vena cava receives the hepatic veins from the liver, before it enters the right auricle (above and to the right). The vena cava lies to the right of the aorta. It is wider than the aorta. The *renal veins* come off at right angles from the vena cava. The left vein is longer and passes in front of the aorta. The renal veins pass in front of the renal arteries and ureters and enter the inner notched border (hilus) of each kidney.

68. **The abdominal aorta and inferior vena cava, kidneys and ureters:** (See fig. 15, p. 52.) The *renal arteries* branch from the aorta at right angles and pass behind the renal veins, in front of the ureters, to enter the kidneys.

Note the *anomaly* (deviation from the ordinary) in this case: There are two renal arteries entering each kidney instead of one. The upper one is in its normal position just behind the renal vein and partly hidden by it. The lower one is one inch below the level of the renal vein on each side.

These pass upward and outward, entering the lower poles at the hilus of each kidney, just behind the beginning of the ureters. Note: Such an anomalous artery may bend (kink) the ureter as it passes from the pelvis of the kidney and may thus obstruct the flow of urine from the kidney (hydronephrosis). The right kidney is somewhat lower than the left. The liver on the right side tends to displace the right kidney in a downward direction.

The *celiac artery* (celiac axis) and the *superior mesenteric* artery arise from the aorta above the renal arteries. The *inferior mesenteric* artery arises about two inches below the renals. (Note: The inferior mesenteric artery passes toward the lower and left part of the abdomen. It supplies the lower part of the large intestine.) (Also see figure 8 and its description.) The *aorta* and inferior *vena cava* divide at their lower ends into two terminal branches, the *common iliac arteries or veins,* each subdividing about two inches further down into an *internal and an external iliac artery or vein.*

Note: *The right common iliac artery crosses in front of and may press upon (compress) the left common iliac vein.* (Figs. 68-69.) This accounts for the more frequent disturbances of the circulation of the *left* leg, such as varicose veins, swollen leg (milk leg) after confinement or operation. The two *ureters* pass from the kidneys at their inner border (hilus), behind the renal veins and arteries, downward and inward, cross in front of the common iliac arteries near their division at the brim of the pelvis, into the internal and external iliac; the ureters then pass along the pelvis to enter the bladder.

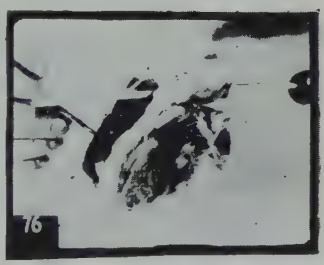
69. The aorta and the vena cava—their relative position in the body: The *aorta* is in front and to the left of the

COURSE OF THE VENOUS BLOOD FROM THE INFERIOR VENA CAVA, AZYGOS VEIN AND SUPERIOR VENA CAVA TO THE RIGHT AURICLE

vertebral column. The *vena cava* is in front and to the *right*. These divide into their terminal branches, common iliac arteries or veins respectively, at the left of the fourth lumbar vertebra, which is about one inch above the brim of the pelvis. Note: The left iliac vein is crossed and compressed by the right iliac artery.

71-81. *Course of Venous Blood* as indicated in an actual dissection of the heart (illustrated by the passage of a metal sound): The blood from the superior and inferior vena cava enters the right auricle, passes to the right ventricle, then through the pulmonary artery to reach the lungs.

71. **Interior view of the chest:** (The heart is turned to the left exposing the *right auricle* and part of the ventricle.) The *superior vena cava* enters the upper part of the right auricle. The *azygos vein* enters the superior vena cava about one inch above the auricle. The *inferior vena cava* passes upward from the abdomen through the opening in the diaphragm, and enters the lower part of the right



COURSE OF THE VENOUS BLOOD FROM THE RIGHT VENTRICLE TO THE PULMONARY ARTERY

auricle. [Should the inferior vena cava become blocked, (thrombosed) blood may still pass, by means of collateral circulation, from the lower part of the body into the right auricle by way of the azygos vein which also collects some of the blood from the region of the inferior vena cava, and enters the superior vena cava.] Note the right side of the chest cavity; its base below at the diaphragm, and the dome, above at the level of the upper ribs.

72. Interior of the right side (chambers) of the heart: (Parts of the walls of the heart are removed to show the interior.) The superior *vena cava* enters the upper part of the *right auricle.* (Metal sound is passed through into the right auricle.) Note the thin walls of the auricles (which are somewhat smaller) as compared to the ventricles. The auricles hold about two ounces, the ventricles about three ounces of blood. The inferior vena cava enters the right auricle at its lower part. At the base of the heart, that is at its upper wider portion, the superior vena cava lies to the right, the aorta, partly covered in front by the upper part of the right auricle (auricular appendage) to its left. The pulmonary artery as it emerges from the upper part of the right ventricle (conus arteriosus) lies at first to the left, and then passes behind the aorta.

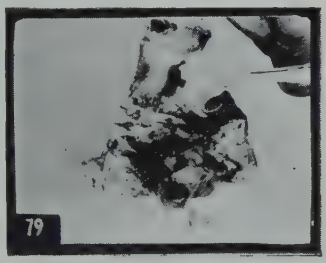
74. **Anterior view of the heart:** The blood passes from the right auricle, through the valve opening (auriculo-ventricular opening) into the *right ventricle* (as indicated by the metal sound entering the right ventricle pointing towards the opening of the pulmonary artery at the conus arteriosus.) Note the partition (ventricular septum) between the right and left ventricles.

The anterior branch of the right *coronary artery* (artery of the heart) lies on the partition between the right auricle and

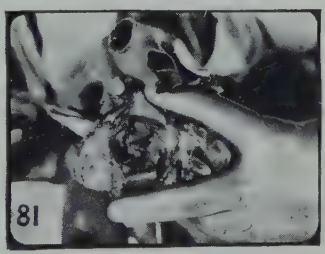
ventricle. The anterior branch of the left coronary artery lies on the partition between the ventricles. Note the tortuous wormlike appearance of the coronary arteries which enables them to lengthen and shorten with each diastole and systole of the heart action. The pointed portion of the heart (*apex*) to the left is composed mostly of the left ventricle. Note that the muscle wall of the left ventricle is much thicker than the right.

76. From the *right ventricle* the blood enters the *pulmonary artery.* (A metal sound is passed from the right ventricle through the pulmonary artery.) To the extreme left is part of the left auricle, which is below the pulmonary artery. Below the left auricle is the left ventricle, which leads upward and to the right, behind the pulmonary artery, into the beginning of the aorta.

79-81. From the pulmonary artery the blood goes to the lungs; through the aorta it passes to the entire body. (See fig. 24, p. 78.)



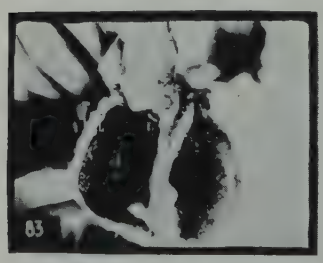
79. A view of the heart from behind and above: To the left and above is the *pulmonary artery* (raised), dividing into a right and left branch. To the right is the beginning of the *aorta* (held to one side by the forceps). Below and to the left is the interior of the *left auricle,* at its lower part is the opening of one of the pulmonary veins and the mitral valve which is exposed in fig. 81.



81. Same as figure 79. Note

the *pulmonary artery dividing into a right and left branch.* The right branch of the pulmonary artery passes behind the root of the aorta on its way to the lungs. Note the stiffer and *thicker* leathery wall of the *aorta* as compared to the *thinner* wall of the *pulmonary artery.* Reason: The left ventricle, which pumps the blood through the aorta, contracts with great force in order to send the blood to all parts of the body; the right ventricle contracts with less force, because it has merely to send the blood through the pulmonary artery to reach the lungs.

The pressure (blood-pressure) in the aorta is much greater (about 120 millimeters of mercury) as compared to the pressure in the pulmonary artery (about 50 millimeters of mercury.) The aorta is therefore made up of stronger tissue material to withstand greater pressure and thus minimize the possibility of being unduly stretched (producing an aneurysm) or torn (causing a hemorrhage). If the pressure in the arteries becomes too great, such as may occur in some cases of arteriosclerosis (hardening of the arteries), it may cause a stretching of their walls (aneurysm) and may even rupture a blood-vessel sometimes producing apoplexy (hemorrhage of the brain) or other hemorrhages, any of which may prove fatal.



83. Anterior view of heart dissection—its ventricles, septum and **the coronary arteries** (arteries of the heart): The blood as it passes through the heart chambers nourishes only its inner lining (endocardium) while the rest of the heart muscle is supplied with arterial blood by two special arteries, the right and left coronary arteries. The

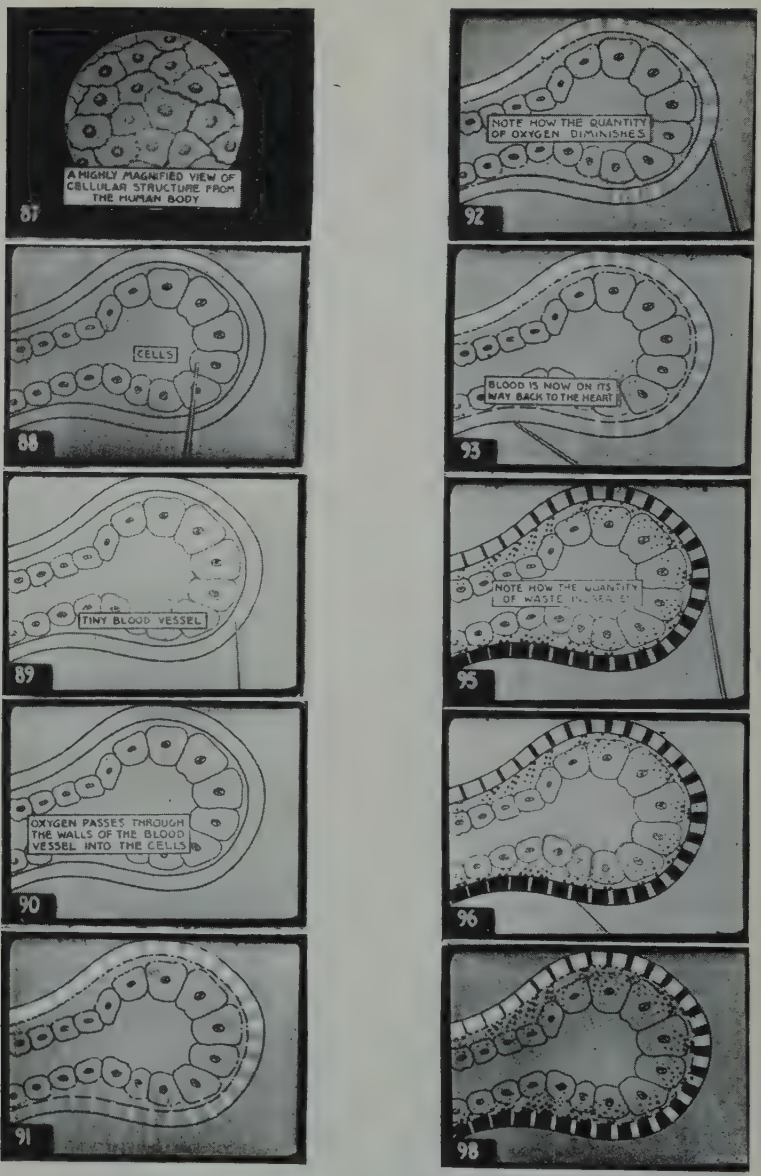
DURATION AND COURSE OF A COMPLETE CYCLE OF THE BLOOD FLOW

venous blood from the heart muscle itself is returned to the right auricle by the coronary veins. Note the anterior branch of the left coronary artery passing over the ventricular septum to supply both ventricles.

The shortest course (cycle) of a drop of blood takes place in the blood-vessels of the heart muscle itself: The arterial blood passes from the left ventricle to the aorta, then through the coronary arteries to the heart muscle, and then returns as venous blood through the coronary veins which enter the right auricle.

84-106. *It requires about twenty-three seconds for the blood to circulate through the entire body,* making about three complete cycles a minute. This fact is utilized to advantage in cases of collapse, heart failure, etc., by the administering of hypodermic injections of stimulants. If, for example, the stimulating drug (strychnine or adrenalin) were injected into a vein of the arm, it would travel from the arm upward to the right chambers of the heart, then to the lungs, back to the left chambers of the heart, to the arteries, and thus reach and stimulate in less than half a minute, all parts of the body such as the brain, abdominal organs, upper and lower limbs, etc.

85. Following the complete cycle (course) of a drop of blood from a given point until its return to the same place: (See fig. 24, p. 78.) From the *lungs* the arterial (red) blood passes through the *pulmonary veins* into the *left auricle,* the *left ventricle,* and then to the *aorta.* From the aorta it passes through the many branches, which end in fine hair-like tubes (*capillaries*), to supply the cells and tissues of all parts of the body with energy (nourishment and oxygen). (See figs. 87-93.) In the tissues, the blood of the capillaries takes back the waste matter including carbon dioxide. (Figs. 95-96.)

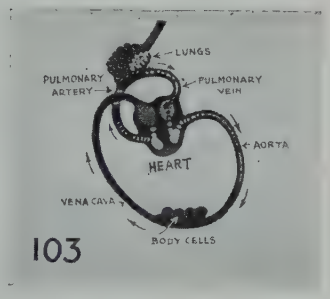


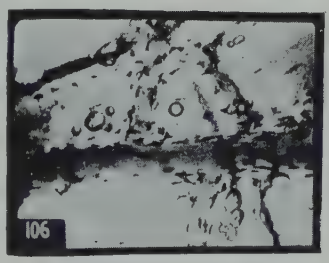
INTERNAL RESPIRATION (DIAGRAMMATIC):
The Exchange of Oxygen and Carbon Dioxide Between the Blood and the Body Cells

EXCHANGE OF MATERIAL BETWEEN BLOOD AND BODY TISSUES, AND BETWEEN BLOOD AND LUNGS

(The exchange of oxygen from the blood for the carbon dioxide in the tissues is called "Internal Respiration.") (Fig. 98.) From the capillaries the blood passes into the *veins,* the branches (tributaries) of which enter from the lower half of the body into the inferior vena cava and from the upper half into the superior vena cava. The venous (blue) blood from the superior and inferior *vena cava* enters the *right auricle,* goes to the *right ventricle,* then to the *pulmonary artery* (the only artery carrying venous blood) to reach the *lungs,* where it absorbs the oxygen and gives up its carbon dioxide (which change is called "External Respiration") and again becomes arterial to start back to the heart. (See fig. 11, p. 75, and figs. 87-98.)

100-105. Diagrammatic view of the heart with the blood-vessels leading to and coming from the tissue cells of the body, together with the blood-vessels leading to and coming from the lungs (the white dots representing the oxygen, the black dots the carbon dioxide). The lungs (fig. 100) (indicated by the pointer) give up the oxygen to the blood which passes as arterial blood into the pulmonary veins (fig. 101) to enter the left auricle, then the ventricle (fig. 102), from where it is pumped through the aorta (fig. 103) to all tissues and cells of the body.





103-105. From the tissue cells, where it becomes venous, the blood passes through the vena cava into

FACTORS MAINTAINING THE PROPER FUNCTIONING OF THE CIRCULATORY SYSTEM

the right auricle and ventricle from there to be pumped through the pulmonary artery to the lungs, here giving up its carbon dioxide in exchange for oxygen (as presented in black and white dots (fig. 105).

106. *The actual flow of the blood as seen through a microscope:* In the center is a small artery (in a horizontal position) and its branches filled with the corpuscles of the flowing blood. The flow rhythmically increases with every contraction (systole) and slows down with every pause (diastole) of the heart-beat. (See fig. 11, p. 57.)

109-114. The proper functioning of the Circulatory system requires: (1) A heart of good muscular quality (tone), with its properly fitting valves regularly beating with even force, about 72 times a minute; (2) A set of healthy elastic tubes (blood-vessels) through which the blood is propelled to all parts of the body; (3) A definite amount of pressure (blood-pressure) of about 120 millimeters of mercury to overcome the resistance offered to the blood as it passes through the blood-vessels and tissues of the body.

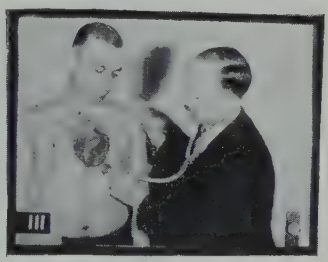
A physician can tell the rate of the heart-beat, the force of the heart action, and the condition of the blood-vessels by feeling the pulse (fig. 109), by listening to the heart (fig. 111), and by taking the blood-pressure (figs. 113-114).

109. **The Pulse:** With every contraction (systole), the heart pumps about six ounces of blood into the elastic arteries. These arteries expand (pulsate) to make room for the additional amount of blood, and then contract to force the blood onward to the tissues of the body. This expansion and contraction of the arteries (rhythmic pulsation) is referred to as the pulse. The pulse is best observed where a sufficiently large artery is accessible near the surface of the body under the skin, such as at the wrist or temple.

PULSE—HEART SOUNDS—BLOOD-PRESSURE

Feeling the pulse at the wrist: Two fingers (index and middle fingers) are placed over the artery at the wrist (radial artery) where it can be felt pulsating (expanding and contracting).

One may observe, by feeling the pulse—(1) *Rate:* the number of beats (pulsations) per minute (the average is 72 which corresponds to the number of heart-beats); (2) *Regularity:* whether it skips a beat, whether it goes slower or faster, etc.; (3) *Compressibility:* whether it requires moderate pressure of the finger to obliterate the pulse, that is to prevent the blood from passing through the artery, or it requires much pressure (which indicates high *blood-pressure*).



111. **Listening to the heart** with a stethoscope: The heart is nearest to the chest wall (especially its lower pointed part, the apex), about two inches from the left of the midline at the level of the fifth rib. One can observe, by listening to the heart, the rate, regularity and force of the *heart action,* also the presence of *heart murmurs.* The murmurs are generally caused by inflammation and

roughening of the linings of the heart and its chambers. The openings at the valves become narrowed (stenosis) and do not fit tightly, causing a leaking backward (regurgitation) of the blood at the valves.

113-114. **Taking the blood-pressure** (fig. 113) by means of a blood-pressure apparatus: The arm above the elbow is compressed while the pulse is felt at the wrist. The amount of pressure over the artery of the arm (brachial artery) necessary to compress it and thus stop the flow of blood at the wrist (as indicated by the disappearance of the pulse at this point), is the blood-pressure. (Fig. 114.) The blood-pressure is registered on the apparatus (mercury sphygmomanometer) in terms of millimeters of mercury. The average blood-pressure ranges from 120 to 140 millimeters of mercury. The normal blood-pressure for the average individual of twenty should be about 120, and in one of forty, the blood-pressure should be about 140; *i.e.*, 100 plus the age. When the blood-pressure falls considerably below normal, that is 70 or 80, this indicates heart failure or a weakened condition of the heart action. If the blood-pressure is considerably above normal, that is about 170 or 190, this indicates abnormal conditions of the circulatory system such as arteriosclerosis (hardening of the arteries), etc.

116. The function of the Circulatory system then, is to supply energy constantly to all tissues of the body, and remove from them all the waste material. The heart engine and its many blood-vessels are, as a result, subjected to a constant wear and tear, a continuous strain which nature is ever striving to overcome by reparative processes. These processes of repair which are so essential to life and good health, may be aided considerably by the inculcation of proper hygienic habits and a regular mode of careful living with adequate and thoughtful provision for work, rest and recreation. This also

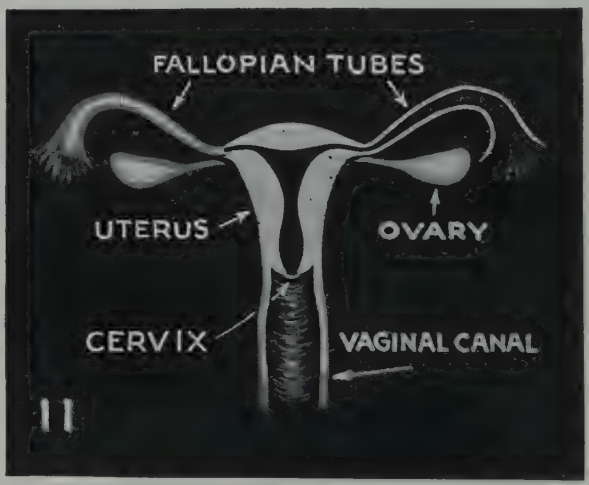
THE PROPER FUNCTIONING OF THE CIRCULATORY SYSTEM

enables the complex machinery of the human body to work in harmony, entailing the least amount of wear and tear, and helps to maintain the normal rate and force of the heart action, and the normal blood-pressure, both of which are indispensable to good health.

REEL 6—REPRODUCTIVE SYSTEM AND HUMAN DEVELOPMENT

THE ORGANS OF GENERATION: PHYSIOLOGY OF REPRODUCTION

The development of human life has always been a fascinating phenomenon. It is indeed indicative of our progress to find that with recent years has come the abandonment of all prudery which formerly surrounded any discussion of this subject. The intelligent student of to-day, fully aware of



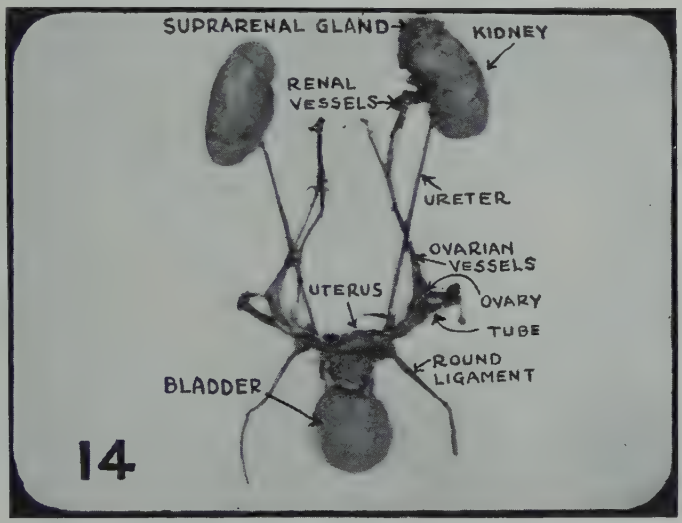
the possibilities which may be realized from greater knowledge of the process of life, is beginning to display a commendable, frank and eager interest in the various phases of development from the seed to full growth.

The organs concerned in the process of reproduction—the female *reproductive organs*, the *uterus, tubes* and *ovaries*—are situated in the lower portion of the abdomen called the pelvis.

ORGANS OF GENERATION: ANATOMICAL RELATIONS OF THE REPRODUCTIVE AND URINARY ORGANS

These organs communicate with the outside through the vaginal canal.

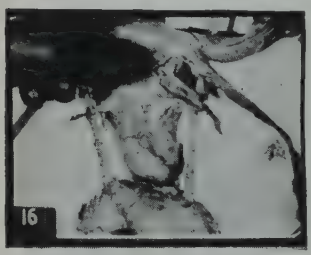
11. Diagrammatic presentation of the reproductive organs: the *uterus* is in the center, showing its interior or cavity. From the upper end of each side extends a *Fallopian tube.* The right one is shown closed while the left one is cut across to show its interior. Below each tube to either side of the uterus is an almond shaped body, the *ovary,* attached to the uterus by its ligament.



13. **The uterus** is a pear-shaped hollow muscular organ, in which the ovum is received and the offspring nourished and kept until birth. In nulliparæ (those who have never borne children) the *uterine cavity* holds only about half a teaspoonful. The portion of the uterus above the opening of the tubes is called the *fundus;* the upper wider portion, the *body;* the lower conical portion the *cervix* (the neck of the uterus).

THE UTERUS—ITS RELATION TO URETERS, BLADDER, OVARIES, TUBES, AND ROUND LIGAMENTS

14. **Dissection of the reproductive and urinary organs** of an adult female, including the uterus, tubes, ovaries and round ligaments, kidneys, ureters and bladder—placed as they appear in their relative normal position in the body: The *uterus* is in the center, close to bladder. To either side of the uterus are: the *round ligaments* in front, the *tubes* in the middle, and the *ovaries* in the back. Above, to either side, are the right and left *kidneys.* The *ovarian arteries,* which are branches of the aorta, together with the *ovarian veins,* pass downward and outward, cross in front of the ureters and then go to supply the ovaries, tubes and uterus. The left ovarian vein enters the left renal vein, while the right enters the inferior vena cava. The *ureters* pass from the inner border (hilus) of each kidney, downward and inward behind the ovarian vessels, underneath the broad ligaments, below the tubes and ovaries, and pass alongside the uterus and vaginal canal, to enter the bladder.



15. A close-up of the uterus, tubes and ovaries: The *uterus* is about three inches long, two inches wide and one inch thick. The body of the uterus, together with the fundus, is bent forward (*anti-flexed*) at an angle at its lower part —the cervix. The *fundus* and posterior surface of the uterus are con-

vex. To either side of each angle (*cornu*) of the uterus is the *round ligament* in front, the *Fallopian tube* in the middle, and the *ovary* in the back. The *ureters* pass from above downward through the folds of the broad ligaments, under the ovaries, tubes and uterine arteries, to either side of the uterus and vaginal wall, before they enter the bladder. (See fig. 22, p. 54.) To the right, the ligament going from the uterus to the ovary (*ovarian ligament*) is seen behind the Fallopian tube. To the left, the ovary with its blood-vessels is seen behind the Fallopian tube.

16. The *uterus* is above and behind the *bladder*. As the bladder becomes filled it raises and pushes the uterus upward and backward. To either side of the uterus and vaginal canal are the *ureters*, which pass underneath the uterine arteries to enter the bladder. (The surgeon may avoid accidentally cutting the ureters during the removal of the uterus, which occasionally becomes necessary because of its pathological condition, by holding the uterus to the opposite side, thus separating it from the ureters, and then cutting close to the side of the uterus.) The *round ligament* (on the left side) is seen in front of the ovary at the cornu of the uterus.

18. **The ovaries** are two almond shaped bodies, situated to either side of the uterus. They are the female reproductive glands in which the *ova* (sex cells) are formed. Each ovary is attached at its inner end, to the uterus by a ligament (the *utero-ovarian ligament*). (See fig. 11, p. 96.)

19. To either side of the cornu of the uterus are the ovaries and their ligaments behind, the Fallopian tubes in the middle, and the round ligaments in front. (See fig. 14, p. 97.)

20. The left *ovary* and *tube* are held apart to show the *ovarian artery* coming from above giving off its branches to the ovary and tube, and going down to unite (anastomose)

with the *uterine artery*. To the extreme left is the fimbriated extremity of the Fallopian tube; some fimbria are attached to the outer pole of the ovary by a ligament (the *fimbro-ovarian ligament*). The innermost narrow portion of the tube entering the uterus is called the *isthmus;* the wider middle portion (held in forceps) is the *ampulla;* the outer dilated free portion is the *fimbriated extremity*. (See fig. 11.)

20-23. **The Fallopian tubes** are two canals that convey the ova from the ovaries into the uterus. (See fig. 28.)

22. The right tube is shown closed. Its inner conical portion (isthmus) is narrow. The middle portion (*ampulla*) is wide. The outer third (*fimbriated extremity*) is trumpet-like, with many fringes. The left tube is cut across to show the interior with the many folds (rugae) of its mucous membrane.

EMBRYOLOGY: HUMAN DEVELOPMENT

The various processes of human development which take place before birth are termed, in their chronological order: *Ovulation, Fertilization, Segmentation, Implantation, Growth* and *Maturity*.

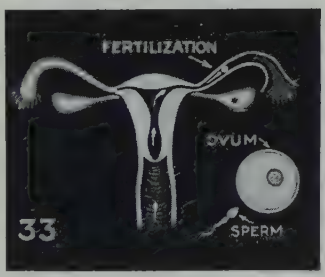
25-26. The fertilizing elements consist of the ovum and spermatozoon. The *ovum* is the female and the *spermatozoon* is the male sex cell. The ovum (see fig. 33) consists of a soft jelly-like material (*protoplasm*) surrounded by a delicate membrane containing a rounded body (*nucleus*) which possesses the vital elements of the cell. All the *cells* constituting the body tissues are similarly constructed.

At puberty each ovary contains about thirty-five thousand ova. The *ovum* is 1/125th of an inch in diameter.

26. The spermatozoon is 1/500th of an inch in length. (See fig. 33.)

OVULATION—FERTILIZATION

28. *Ovulation:* The female sex cells (*ova*) develop and ripen in the ovary. When ripened, they come to the surface enclosed in a thin sac (*Graafian follicle*). Once a month (after puberty and up to menopause) one or more of these follicles rupture, from which the ova escape. This process is called *Ovulation.* About one week following the ovulation, *menstruation* takes place. It is a periodic escape of a sanguinous fluid from the uterus. When the ovum is discharged from its nest (Graafian follicles) in the ovary, it passes into the Fallopian tube (see fig. 28). From the tube the ovum passes into the uterus and escapes with the menstrual fluid, unless conception occurs.



30-33. *Reproduction* begins with fertilization of the ovum by the spermatozoon, which occurs in the Fallopian tube. The spermatozoon has *motile power* and by means of its tail, directs the course from the entry, passing through the uterus into the Fallopian tube, where it meets the ovum. (See fig. 33.)

33. *Fertilization* generally takes place in the Fallopian tube. (Should two ova be fertilized instead of one, *twins* may develop. In a similar manner triplets or quadruplets may develop.) The ovum then passes into the uterus. Should the fertilized ovum remain in the tube, false pregnancy (ectopic gestation) may take place. After the ovum has grown in the tube for a period of weeks or months, it generally ruptures, sometimes producing a fatal hemorrhage.

FERTILIZATION

The ovum may be fertilized at the fimbriated end of the tube, after which it may fall into the abdominal cavity where it may become attached and grow, producing *abdominal* pregnancy. Again, the Graafian follicle sometimes ruptures but here the ovum remains in the ovary. The spermatozoon may then pass through the Fallopian tube to fertilize the ovum in the ovary, resulting in *ovarian pregnancy.* Tubal, abdominal and ovarian pregnancies are abnormal, never go to full term, and often result in severe internal hemorrhages, requiring surgical aid.

35-37. *Fertilization:* The spermatozoon reaches and enters the ovum, which thus becomes fertile.

37-39. Though more than two million spermatozoa are emitted during copulation, only one spermatozoon enters the ovum. As it reaches the ovum a conical projection (*cone of attraction*) appears on the surface of the ovum (fig. 37) through which the spermatozoon enters, leaving the tail behind. (Fig. 39.)

39. As soon as one of the spermatozoa enters the ovum the rest are barred by the membranous formation at the cone. Should another happen to enter, the ovum may develop abnormally and may produce monstrosities.

40-46. The *spermatozoon* without its tail assumes the form of a nucleus (*male pronucleus*). It approaches the nucleus of the ovum (*female pronucleus*) with which it fuses, forming the combined nucleus (*segmentation nucleus*) which contains the male and female nuclear substances. Each thus imparts

THE STAGES OF FERTILIZATION: PROPHASE—METAPHASE—ANAPHASE—TELOPHASE

its respective male and female individuality of the parents to the future embryo.

40-57. The various changes which take place from the time the spermatozoon enters the ovum until it becomes ready for segmentation (division) are called *prophase, metaphase, anaphase* and *telophase.*

40-47. **Prophase** (the fusion of the male and female nuclei): The *centrosome* (a minute round body with two stained particles alongside the nucleus) divides into two *centrioles.* (Figs. 40, 41.) The centrioles move apart to the opposite sides of the nucleus. (Fig. 42.) The *chromatin* (a network of fibers in the nucleus) becomes arranged into a number of segments (*chromosomes*) (figs. 43-44.) Chromosomes from both nuclei, ovum and spermatozoon, arrange themselves in the center between the two centrioles (figs. 45-47). It is believed that the presence of an odd or even number of chromosomes in the male nucleus determines the *sex* of the offspring, a male developing when the number is odd (such as twenty-three chromosomes), a female when the number is even (such as twenty-four).

SEGMENTATION—TWINS

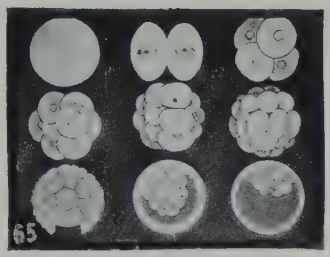
47-50. *Metaphase* (division of the chromosomes): Each chromosome divides longitudinally into two separate halves (*daughter chromosomes*) along the line of the equator of the fibrils of the *achromatic spindle.* (See figs. 49-50). (Achromatic spindle is the line of fibrils arranged like a spindle between the centrioles as its poles.)

50-56. *Anaphase:* (formation of the daughter nuclei). The divided daughter chromosomes along the equator of the spindle (see fig. 50) travel in opposite directions along the fibrils of the achromatic spindle towards the centriole (see figs. 51-52). They group themselves at each pole of the spindle, forming two star-like bodies (di-aster)—(see fig. 53) eventually forming two nuclei (see figs. 54-55); each one having half of the chromosomes of the male and female (ovum and spermatozoon).

57-58. *Telophase* (division of ovum): The ovum thus fertilized begins to divide and multiply (*segment*).

By the same process of cell division (*mitosis*), the invariable loss of the many cells of the body tissues which results from the constant wear, tear and occasional injury to which the tissues are subjected, is continuously replaced during life by the formation of new cells (*regeneration*) from the existing tissues. Should the cell activity (mitosis) go beyond normal limits, because of continuous

THE THREE LAYERS OF CELLS: ECTODERM—MESODERM —ENTODERM



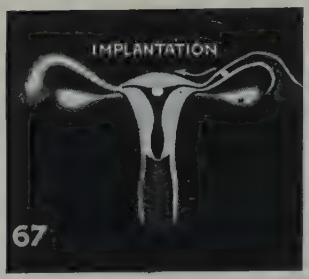
irritation or other unexplainable causes, an excessive amount of tissue may develop, resulting in the formation of exuberant *scars, callus* or *tumors.*

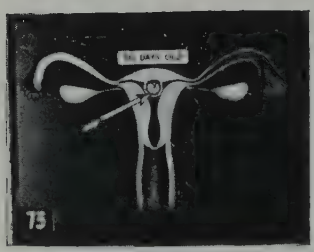
57-60. **Segmentation:** The fertilized ovum divides into many segments (cells), which continue to grow and multiply. The ovum divides into two cells, which again divide into four—eight—sixteen, etc., until thousands of cells are formed, in the shape of a round, globular mulberry mass (*morula*), covered with a membrane. This process of cell division represents the earliest stages of the development of the individual offspring.

58. Should the first few divided cells completely separate from each other and continue to develop and grow, *twins* may result from the same ovum. Twins developing from one ovum resemble each other very closely and are generally of the same sex, while twins developing from separate ova may be of a different *sex* and their *resemblance* is not so close.

61-65. The various cells or sets of cells become assigned to develop different parts or organs of the body. The cells become arranged in three layers; an outer layer called the *ectoderm;* an inner layer (figs. 61-62), the *entoderm,* and between these two layers, a middle layer called the *mesoderm.* The process of segmentation, up to this point (fig. 65), takes place in the Fallopian tube, while the fertilized ovum is traveling from the tube into the uterus, which takes about six to eight days. During this time thousands of cells are formed which

GROWTH OF EMBRYO IN UTERUS





become arranged into outer, middle and inner layers.

From the outer layer (**ectoderm**) develops the skin, the hair, the nails, the skin glands, the enamel of the teeth, the lining of the mouth and nose, the lower part of the rectum, and the nervous system.

From the inner layer (**entoderm**) develops: the mucous membrane lining the digestive tract and the epithelium of the various glands associated with it; the lining (epithelium) of the larynx, trachea and lungs, bladder and urethra.

From the middle layer (**mesoderm**) are formed the various connective tissues, including bones, muscles, circulatory system, the blood-vessels, the lining of the various serous cavities, the kidneys, ureters, and the organs of the reproductive system.

67-69. **Implantation:** The fertilized ovum passes from the tube (fig. 67) into the uterus (fig. 68) where implantation (taking root) occurs. It becomes attached and firmly imbedded in the thick velvety lining membrane of the uterus where it receives its nourishment and from which site a membrane (*the decidua*) is reflected which in time completely surrounds the ovum (fig. 69). Following conception, during the period of gestation, menstruation is generally suspended.

A FETUS AT THREE MONTHS—THE UMBILICAL CORD, PLACENTA AND MEMBRANES

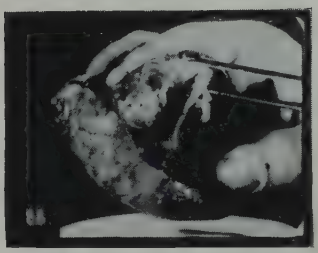
The implanted ovum continues to grow and develop into the *embryo,* and then into the mature *fetus.* It is nourished and kept in the uterus until birth. (See figs. 68-97.)

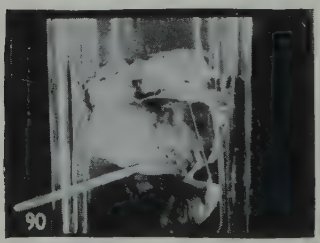
71-73. In two weeks the embryo (fig. 71) grows from the ovum 1/125th of an inch to ¼ of an inch (size of a lima bean). At four weeks (fig. 73) it is the size of a walnut.

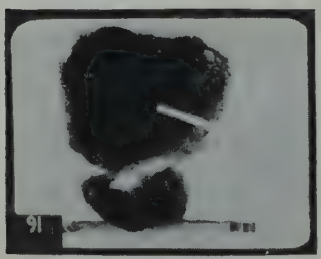
75, 76. The *uterus* and its *cavity* enlarge progressively to accommodate the growing embryo and fetus. At *two months* the muscle wall of the uterus becomes ¾ of an inch thick and its cavity is about the size of a hen's egg. (See fig. 75.) At *three months* it enlarges to the size of a goose egg. (Fig. 76).

77. The embryo (see fig. 99, p. 109) is enclosed in its sac (*amnion*), which becomes attached to part of the wall of the uterus, which later becomes the site for the *placenta.* The rest of the sac (*membrane*) fits the inner wall of the uterus. In the human embryo of seven weeks, the eyes, the head, and the limbs become visible,

FUNCTION OF THE PLACENTA, MEMBRANES AND AMNIONIC FLUID







and the body begins to take form.

79. A *two month* human embryo: Observe the large head, the projecting limbs, the eyes, and the curved back.

80. A *six weeks* embryo as it lies in the Fallopian tube, in a case of false pregnancy (ectopic gestation).

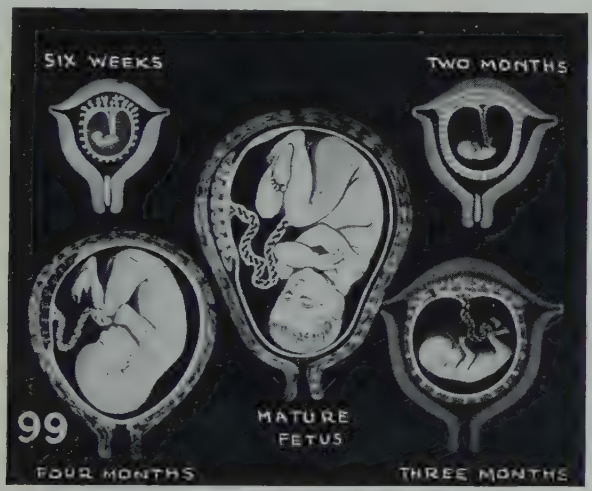
83-84. View of the fetus as it lies in its membranous sac filled with fluid. The *sac is thin* and transparent, like the skin of an egg.

85. At three months the fetus is surrounded by a membranous sac (*amnion*), filled with amnionic fluid in which it floats. The fetus is connected by its *umbilical cord* to the *placenta* which is attached (embedded) to the wall of the uterus. A fetus of twelve weeks definitely resembles a human being. (Figs. 99, 87, 88.)

87-88. In a fetus of three months (fig. 87) all the parts become distinct, the sex distinguishable, the umbilical cord (fig. 88) and the placenta are well formed.

90. *A three month fetus*—The membranes which surround it are

cut away to show clearly the *fetus, umbilical cord* and *placenta:* The fetus receives its nourishment through the blood-vessels of the umbilical cord which connects the fetus to the maternal organism (the unborn to its mother) by means of the placenta. The *umbilical cord* consists of *one* vein and *two* arteries entwined and surrounded by a gelatinous substance (*Wharton's jelly*). It is attached at one end to the *navel* of the fetus and at the other end to the smooth inner lining of the *placenta.* The



length of the cord is equal to the length of the fetus. **Fetal nourishment** passes from the mother's blood through the placenta into the umbilical vein to reach the fetus. The waste matter from the fetus passes from the *fetal blood* in the *umbilical arteries,* through the *placenta* from where it is taken up by the *mother's blood* to be eliminated by the excretory

organs. *The placenta therefore is the exchange depot and the umbilical cord the connecting link* through which the fetus receives its nourishment and gives up its waste products.

91. The outer surface of the placenta is rough, divided into many sections, covered with many moss-like projections (*villi*) which attach themselves onto the wall of the uterus.

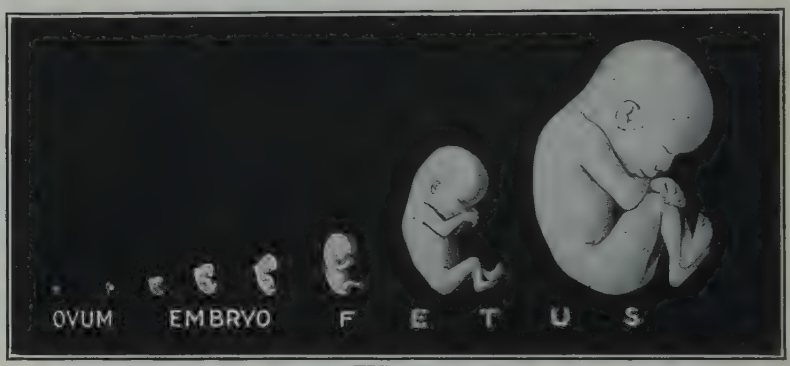


FIG. 101

93. The fetus floats and moves about in the liqiud of its membranous sac. The membranous sac (*amnion or water bag*) with its amnionic fluid, surrounds the fetus, serves to protect it from injury or jarring and allows the fetus freedom of movement. (See figs. 93, 99.)

95-99. **Life** (fetal movement) is first noted at about four months (see fig. 99). As a result of its growth the fetus becomes crowded in the uterus and accommodates itself in a position to take up the least space. The head is down in the pelvis towards the birth canal, the body and the limbs are flexed. The mother at about this time begins to feel the movements of the fetus (*feels life*).

97. **Mature fetus** (see fig. 99): The organs and limbs are well formed. The head is now covered with hair. The nails

are distinct and project beyond the finger tips. The skin is pink and firm, well lubricated with fat (vernix caseosum).

99. A view of the fetal development in the uterus at various stages: at six weeks, at two, three and four months and the mature fetus.

101. View of the successive stages of the development of the Ovum, Embryo and Fetus.

The *Mature Fetus* (fig. 99) almost completely fills the cavity of the uterus lined by the membranous sac (*amnion*). The sac contains about a pint to a quart of *amnionic fluid.* The *umbilical cord* is about twenty inches long and one inch thick. Two hundred and eighty days following fertilization, when *birth* is about to take place (fig. 97) the *uterus contracts,* forcing down the membranes (water bag) which first *dilate the birth canal,* and then, being rather thin, the *membranes rupture.* The amnionic *fluid escapes* and is soon followed by the *birth of the child,* fifteen minutes later, by the *expulsion of the placenta* (after-birth) and its membranes. The uterus then continues to contract and becomes smaller in size (*involutes*) until it reaches almost the size previous to pregnancy.

The new-born begins to breathe immediately following birth. Its previous fetal circulation is instantly readjusted to allow the blood to pass to the lungs in order to obtain the necessary oxygen for its independent existence. The development of the various organs and systems of the body are thus potentially completed and perfected to begin an individual existence, to perform the various functions, and in time progress through the various stages of development, such as infancy, childhood, adolescence and maturity.

The study of the human body; the phenomenon of human development, its structure and functions, then, have a fascination equaled only by its importance in connection with

eugenics with "healthy forebears" as its keynote. The quality of the fertilizing cells, the fertilization of the ovum, the diverse successive stages of the growth and development of the ovum, embryo and fetus; the construction of the various parts of the body and their functions; all of these are perhaps the most interesting study known to man. Their very delicacy and importance commend at all times most thoughtful care and consideration.

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If this work has served to enable the student to follow more closely the study of the human body because of the presentation of this subject in the form of a "visual text" and has thus stimulated an interest in a better understanding of that most intricate mechanism, the human body, helping to clarify some biologic facts hitherto vague in the mind of the reader, the author will feel fully repaid for his efforts.

INDEX

INDEX

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